THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 59 — Thursday, November 10, 1938 — No. 1160

PUBLISHED WEEKLY

Subscription Terms : 17s. 6d. per annum.
Foreign and Colonial : 20s. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL
8, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address : "Zacatecas, Rand, London."
Telephone : Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen

The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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Works Visits

We have always attached the utmost importance to the visiting of works by technical societies, because we have concrete evidence of their beneficial results. In one case, a method of making cylinders was shown to a party of visitors, and one of them, in no possible way a competitor, immediately adopted the process, thereby saving his firm many hundreds of pounds spread over the years. In a second, the general manager of a foundry being visited gave an impromptu talk on his method of handling orders, illustrating his remarks by examples from the filing cabinets. This talk, helped by later correspondence, resulted in the remodelling of the system used by one of the guests. Each of us could amplify from personal experience some benefit or tip which has been acquired.

Works visits are particularly important for the younger people of the industry, and it was with this in mind that we first suggested the holding of joint meetings between Branches of the Institute of British Foundrymen. It is fairly obvious that in each district most of the largest and up-to-date foundries have been visited at one time or another, but probably not by those who have only recently joined up; moreover, any date chosen would not be convenient for everybody. Thus, by asking the members of another Branch to meet in joint conference, conditions are created for a second visit to the "show" foundries within a reasonable lapse of time, to the especial benefit of those previously precluded by youth or *force majeure*.

It is thus somewhat disturbing to learn that a large number of foundries well known for their broad-minded policy of welcoming visits from the technical societies now find themselves, by Government orders, obliged to close their doors. It must be assumed that there are certain departments and operations which, by their very nature, are to be kept as secret as human endeavour can make them, and under no conditions would it be wise for any departure from the rule to be made. It can also be reasonably assumed that there is a second class from which it is desirable to exclude *strangers*. This word offers a chance for an approach to be made to the Government departments. We suggest a Government department which has imposed such a veto should allow firms to receive members of technical organisations provided that a guarantee as to the integrity of each visitor is given, and that certain departments be omitted from the route of inspection. It could be argued that, amongst those admitted, there might be an odd person capable of revealing secrets to unauthorised persons, but the potential danger always exists and it would not be materially increased if a system such as we have indicated made the visitor no longer a "stranger" from the Government point of view. It must be admitted that it would throw a certain amount of work on people who are perhaps already overworked, but those who have reached middle age should not forget the advantages they themselves have derived in the past and find a means of assuring similar benefits to the rising generation. We do not suggest the creation of a passport system, which is liable to abuse, but rather the issue of personal invitations to approved individuals.

The situation with respect to the visiting of works is exactly like the international political situation, and, indeed, is a reflection of it, inasmuch as it is never static. In the decade after the war practically every foundry was open, but since the rearmament programme was started, door after door is being closed. The extent of this movement can be gauged by an announcement by a society secretary in an area containing hundreds of foundries that he was experiencing the greatest difficulty in procuring an invitation for a works visit. Surely the need of the State departments for secrecy can be reconciled with the desire of technicians for a particularly useful form of education? Finally, those foundries which are free from any restriction will be very materially contributing to the enlightenment of technicians if, under the present conditions, they accede to extra calls upon their generosity.

Book Reviews

Giesserkunde mit einem Anhang Fachrechnen (Foundry Science with a Supplement on Technical Calculations). By Dipl.-Ing. H. Fettweis and L. Fredi. 2 vols. Published by Verlag von Julius Beltz, Langensalza, Germany. Price for the two volumes, 4 marks.

The reviewer has no pretensions to an extensive knowledge of German, but he felt competent to write about the contents of these two volumes because they are based on the printing of a maximum number of the clearest of clear illustrations, accompanied by a minimum of letter press. It is obvious that the book has formed the basis of a series of lessons and probably originated in the school attached to Krupps works in Essen.

The earliest sheets describe the tools of the trade, ranging from trowels, and rammers using compressed air, right through to dividers and calipers, and finishing with simple sand-testing apparatus. Methods of core making are followed by notes on boxes and air hoists, and the handling of patterns in the foundry. Here, as throughout the book, the pages are garnished with *Richtig* and *Falsch*, or the right and wrong methods to employ. Such questions as jointing, use of gaggers, venting, stripping, turning over boxes, runners, gating, slag traps and risers are all dealt with in the simplest possible manner. Chaplets, weighting and clamping of boxes, ladle practice and casting typify the general sequence of the contents, though by no means complete them.

Vol. II is designed for the more advanced students, and includes a modicum of metallurgy, a survey of melting practice, making pattern-plates, core setting, box pins, contraction, and more about feeding problems—a very interesting section this must be to judge, as only the reviewer can, from the illustrations. This remark also applies to the methods available for the elimination of draws. Welding, die-casting and safety first are included just before (as in the case of the first volume) the contents revert to foundry calculations. We do not believe that any of the subjects are dealt with in any other way but that of the most elementary approach such as is essential for teaching. These two volumes are unquestionably the best the reviewer has ever seen for the teaching of foundry practice to apprentices, and they ought to be translated and made available to the foundry classes in English-speaking countries. V. C. F.

The Gantt Chart. 2nd Edition. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price 5s. net.

The fact that the second edition has followed so quickly on the first confirms the excellent opinion the reviewer originally received. In writing of the first edition, he stressed its value to works managers and to heads of departments. The present edition is enlarged by charts actually used in British works. J. W. G.

Catalogue Received

Electric Chain Blocks. Whilst most foundry managers have now come to regard Herbert Morris, Limited, of Loughborough, as specialists in mechanical moulding plants, the bulk of the population most probably identifies this firm with the manufacture of pulley blocks. An eight-page pamphlet (No. F.96) just received reinforces the above statement, for after giving the technical properties, the balance is devoted to illustrating the applicability of the electric chain block for handling an amazing variety of industrial products during the course of manufacturing processes.

World Supplies of Bauxite

The rapidly increasing use of aluminium and light alloys in industry, especially in aircraft and motor vehicles, gives this metal particular strategic importance at the present time. It is therefore of interest to review the world's resources of bauxite, the raw material from which aluminium is produced.

A preliminary review issued by the Aluminium Information Bureau shows that virtually all the world's supply of bauxite is produced in ten countries, namely, France, Hungary, the U.S.A., Dutch Guiana, British Guiana, Italy, Jugoslavia, the U.S.S.R., the Dutch East Indies and Greece. The last two countries are new producers, their output being negligible prior to 1935. Table I, prepared from statistics issued by the Metallgesellschaft, shows that every bauxite-producing country has made substantial progress since 1935. It must be noted that these figures do not necessarily give an accurate indication of the quantities of aluminium obtainable, since bauxite from different sources varies widely in composition and in moisture content.

TABLE I.—*World Bauxite Production in Metric Tons.*

	1935.	1936.	1937.
France	512,900	649,500	688,200
Hungary	245,600	368,900	510,000
U.S.A.	237,700	378,000	425,000
Dutch Guiana ..	115,200	233,900	392,300
British Guiana ..	113,000	172,200	305,600
Italy	170,100	262,200	370,400
Jugoslavia	216,200	278,600	357,800
U.S.S.R.	130,000	200,000	230,000
Dutch East Indies	9,900	133,700	199,000
Greece	9,500	129,900	122,300
Germany	8,300	12,600	18,000
Other countries ..	16,000	14,000	34,800
World total ..	1,784,400	2,833,500	3,653,400

France, though the leading producer, shows the smallest increase, production in 1937 being 34 per cent. higher than in 1935. Production in Dutch Guiana has increased to nearly 3½ times, and in British Guiana to over 2½ times, the quantity produced in 1935. Production has more than doubled in Hungary and in Italy, while the U.S.A., Jugoslavia and the U.S.S.R. show increases of 78 per cent., 65 per cent. and 77 per cent. respectively. Germany is second only to the U.S.A. as a producer and consumer of aluminium, but has only small domestic supplies of bauxite. The raw material for Germany's aluminium is obtained from Hungary, Jugoslavia, France and Italy.

About 60 per cent. of Britain's requirements of aluminium is imported in the form of metal, principally from Canada, but the remaining 40 per cent. is produced chiefly from imported bauxite.

Company Reports

Johnson & Phillips, Limited.—Interim dividend of 5 per cent.

Glenfield & Kennedy, Limited.—Interim dividend of 5 per cent.

Colvilles, Limited.—Interim dividend on the ordinary stock of 3 per cent.

Brown Bayley's Steel Works, Limited.—Dividend of 10 per cent., making 15 per cent.

W. H. Dorman & Company, Limited.—Interim dividend of 5½ per cent. on the 11 per cent. non-cumulative preference shares.

John I. Thornycroft & Company, Limited.—Dividends of 7½ per cent. on the participating preferred ordinary shares and 8 per cent. on the ordinary shares.

Dunswart Iron & Steel Works, Limited.—Profit for year to June 30, £47,851; brought in, £17,120; reserve for depreciation, £6,000; reserve for taxation, £3,275; final dividend of 8 per cent., making 14 per cent.; carried forward, £24,146.

Random Shots

A correspondent who prefers to remain anonymous has sent "Marksman" the interesting drawing reproduced below. Its origin is not given, but the honours, it is believed, go to the "Sunday Express." However, it is to be hoped that Mr. Jesson has also kept the cutting, for it should be his best testimonial if he ever wants

"FAIR WEAR & TEAR!"
— A HAMMER SHAFT,- WORN ALMOST COMPLETELY THROUGH BY FINGER AND THUMB —
— AFTER 4 YEARS OF DAILY USE TRIMMING CASTINGS
By a Mr. JESSON, an employee of a BIRMINGHAM Motor Car Works.

THIS HAMMER WOULD HAVE DONE CREDIT TO LONGFELLOW'S BLACKSMITH, SAYS "MARKSMAN."

"trim castings" in anyone else's motor works. One thinks at once of Longfellow's famous Blacksmith:

"....a mighty man is he,
With large and sinewy hands;
And the muscles of his brawny arms
are strong as iron bands."

And there is no doubt whatsoever that after fettling a few hundred of those specials "his brow is wet with honest sweat."

* * *

Amongst the thousands of new stamps which ardent philatelists are having to add to their collections to bring them up-to-date, is one of special interest in foundry circles. It is a Czechoslovakian pictorial, depicting the Skoda works. Everyone knows of Skoda, but to those who took part in the International Conference of 1934, that little stamp should bring back many pleasant memories, not only of Skoda, but of Pilsen itself. And abundant lashings of the cool clean beer thereof!

* * *

The originality of the title of Mr. Hurst's recent lecture, "What we do not Know about Castings," was completely outdone by the originality of the member of council, who asked before the lecture if he would be using lantern slides! Various Branches have been known to stage a few stunts before now, but a lecture on "What we do not Know," with lantern slides, smacks remarkably of a spiritualist meeting.

* * *

"Causes, Symptoms, Prevention and Cure of Foundry Fever" is a title given in a current list of metallurgical abstracts. Foundry fever is evidently a new industrial disease, and there is no doubt that the best treatment for it consists of quenching in water from, say, 500 deg. C., which will no doubt be followed by a period of ageing lasting from 18 to 24 hours, after which the patient should find himself recovered to a tensile strength of about 30 kg. per sq. mm., an elongation of 6 per cent. and a Brinell hardness of about 140. If he isn't ready for a good day's work then, he had better "die-casting" himself away as a foundry waster.

"MARKSMAN."

Cardiff Engineering Exhibition

The Cardiff Engineering Exhibition will be held, under the auspices of the South Wales Institute of Engineers, in Greyfriars Hall, Cardiff, opening on Wednesday, November 16, and closing on Saturday, November 26. On the Wednesday, at 2.30 p.m., the Exhibition will be officially opened by the President (Major E. Ivor David), and on the following Friday there will be a luncheon at the Whitehall Rooms, Park Hotel, Cardiff, and in the evening a dinner and dance at the Park Hotel.

Copper-Steel Castings*

By MARTIN ALEXANDER, B.Sc. (Research Department, Woolwich)

Though a high alloy content in steel castings is often necessary for meeting some special requirement (*e.g.*, magnetic properties, resistance to abrasion, wear, scaling, corrosion, etc.), the main object in the addition of small amounts of alloying elements to steel intended for the manufacture of castings is the improvement of the mechanical properties. In this respect copper offers special promise of utility. Alloy additions are rarely made except in very small amounts solely for the purpose of improving casting properties; it is sufficient that these properties are not impaired by the addition. There is no reason to suppose that small percentages of copper adversely affect the casting properties; in fact, there is some evidence to show that the fluidity of the steel is increased.[1] The effect of copper on the mechanical properties of the steel in the annealed condition is definitely shown by an increase in the yield point and the tensile strength, but the main utility of copper in this direction lies in the susceptibility to temper-hardening which it confers on the steel. This property of copper has been dealt with in numerous publications, but although there is an increasing output of copper-steel castings, especially in America, data referring to the effect of copper on the mechanical properties of carbon steel and of other low-alloy steels are not very complete. An excellent summary of the work of Nehl, Kinnear, Lorig, Zuege and Findlayson on cast steels containing copper has been presented by J. N. Gregg and B. N. Daniloff[2]; data on the temper-hardening effect in cast steels containing copper are given by E. Söhnchen and E. Piwowarsky[3] and also by T. N. Armstrong.[4] The possibilities of influencing the mechanical properties of cast copper steels by simple heat-treatment are indicated in a monograph by W. B. Sallitt,[5] and a recent article[6] by the same author conveniently summarises the properties and uses of copper-steel castings containing up to about 2 per cent. (and sometimes more) of copper.

TABLE I.—*Composition of Steels Investigated.*

Mark.	C. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent.	Cr. Per cent.	Ni. Per cent.	Cu. Per cent.
OUM/N ..	0.30	0.24	0.45	0.032	0.037	—	—	—
OVH/J ..	0.27	0.24	0.60	0.035	0.040	—	—	1.06
OUT/U ..	0.30	0.24	1.21	0.034	0.043	—	—	—
PJT/U ..	0.27	0.21	1.48	0.037	0.040	—	—	1.05
OVA/B ..	0.27	0.24	0.66	0.034	0.041	0.75	—	—
OVP/Q ..	0.28	0.24	0.64	0.036	0.042	0.90	—	1.00
OXN/O ..	0.26	0.23	0.62	0.034	0.039	—	1.40	—
OXU/V ..	0.26	0.22	0.72	0.036	0.040	—	1.49	1.00
OZZ.PAA ..	0.27	0.23	0.66	0.036	0.039	0.61	1.54	—
OZS/T ..	0.31	0.22	0.70	0.037	0.038	0.48	1.36	1.02

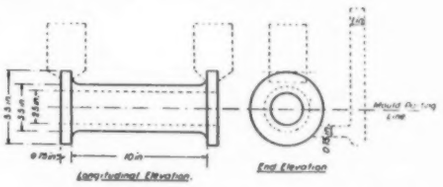


FIG. 1.—DIMENSIONS OF THICK-WALLED FLANGED PIPE CASTING.

An investigation of the effect of copper was carried out on a series of five pairs of steels, one of each pair containing no copper and the other 1 per cent.

The copper-free steels were made in 2-ton charges in a Tropenas converter. The copper-bearing steels were made from separate 2-ton charges, a portion of which was poured into a 10-cwt. ladle to which the necessary addition of copper was made. The compositions of the steels are given in Table I.

Each steel was bottom-poured from the ladle into the following moulds in succession:—(1) Various castings (minimum weight from 10-cwt. ladle, 120 lbs.); (2) multiple spiral fluidity test-

TABLE II.—*Casting Properties of Copper-Steel Castings.*

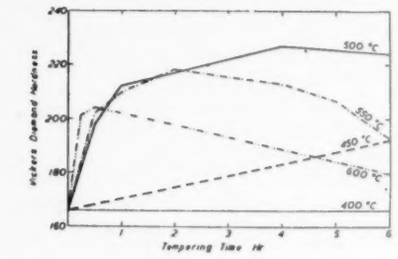
Mark.	Wall thickness. In.	Approx. composition. C. Per cent.	Mn. Per cent.	Cr. Per cent.	Ni. Per cent.	Cu. Per cent.	Crystal form.[1]	Cavities.[2]	Cracks.	Segregation.[3]
OUM	⅜	0.3	0.6	—	—	—	Dendrites in one head.	None.	None.	None.
OUN	½	0.3	0.6	—	—	—	Dendrites in one head.	None.	None.	None.
OVH	⅜	0.3	0.6	—	—	1.0	Normal.	(*a*) Total length 4½ in. (*b*) One 1 in.	(*a*) None. (*b*) Cracked at flange. Decarburisation.	(*a*) Pronounced V-segregation in one head. Subcutaneous banding.
OVJ	½	0.3	0.6	—	—	1.0	Normal.	(*a*) One 2½ in. (*b*) Two 1 in., one ½ in.	(*a*) Crack 4½ in. long in wall.	V-segregation in one flange.
OUT	⅜	0.3	1.5	—	—	—	Normal.	Two ¼ in. in dia.	None.	Subcutaneous banding.
OUU	½	0.3	1.5	—	—	—	Pronounced dendrites in one head.	(*a*) One 1 in. (*b*) Total length 2 in.	None.	Subcutaneous banding. Pronounced segregation in centre of heads. Slight V-segregation in wall.
PJT	⅜	0.3	1.5	—	—	1.0	Pronounced dendrites in one head.	(*a*) Three ½ in. (*b*) One 1 in.	None.	V-segregation in wall. Subcutaneous banding.
PJU	½	0.3	1.5	—	—	1.0	Dendrites in one head.	One ¼ in. in dia.	None.	V-segregation in wall. Slight subcutaneous banding.
OVA	⅜	0.3	0.6	0.8	—	—	Pronounced dendrites in heads.	(*a*) One 1 in. (*b*) One ¼ in. in dia.	None.	None.
OVB	½	0.3	0.6	0.8	—	—	Pronounced dendrites in one head.	None.	None.	None.
OVP	⅜	0.3	0.6	0.8	—	1.0	Normal.	(*a*) One ¾ in. (*b*) Two ¼ in.	None.	Pronounced subcutaneous banding.
OVQ	½	0.3	0.6	0.8	—	1.0	Normal.	One ¼ in. in dia.	None.	Pronounced subcutaneous banding.
OXN	⅜	0.3	0.6	—	1.5	—	Pronounced dendrites in one head.	None.	None.	V-segregation in wall.
OXO	½	0.3	0.6	—	1.5	—	Pronounced dendrites in one head.	(*a*) One 1 in. (*b*) One 1 in.	None.	None.
OXU	⅜	0.3	0.6	—	1.5	1.0	Dendrites in one head.	(*a*) None. (*b*) Two ¼ in.	None	Subcutaneous banding. V-segregation in wall.
OXV	½	0.3	0.6	—	1.5	1.0	Normal.	(*a*) One 2 in. and one 1 in. (*b*) One 4 in. long.	Small cracks in flanges.	V-segregation in heads and in wall.
OZZ	⅜	0.3	0.6	0.5	1.5	—	Pronounced dendrites in one head.	Total length 2 in.	None.	Subcutaneous banding.
PAA	½	0.3	0.6	0.5	1.5	—	Pronounced dendrites in one head.	(*a*) Total length 2 in. (*b*) One 1½ in.	None.	V-segregation.
OZS	⅜	0.3	0.6	0.5	1.5	1.0	Dendrites in one head.	(*a*) One ¾ in. (*b*) One 1½ in. and one ½ in.	Cracks 4½ in. long in wall.	None.
OZT	½	0.3	0.6	0.5	1.5	1.0	Normal.	None.	None.	None.

[1] Normal, *i.e.*, mainly equiaxial with dendritic edge. [2] There were no cavities in the flanges. In the wall, all cavities were elongated (length > width). When there were many cavities in the longitudinal section, the total length is given. [3] Segregation in the immediate neighbourhood of the pipe in the heads is not recorded.

* Extract from the Third Report of the Steel Castings Research Committee (Section III), presented at the autumn meeting of the Iron and Steel Institute in London.

piece (Second Report of the Steel Castings Research Committee, p. 33); (3) three pipe castings (½-in. wall thickness) (Fig. 1); (4) three pipe castings (⅜-in. wall thickness); (5) ingot, 4½ in. by 4½ in., for forging to bar (the properties of this material have been described by Harrison[7]); and (6) sand-cast ingot, 7½ in. in dia.

In the second set of flanged pipe castings the radius at the flanges was reduced to give a sharper angle than shown in the diagram, and



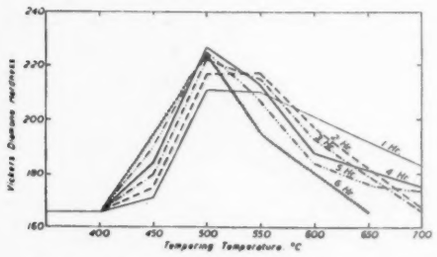
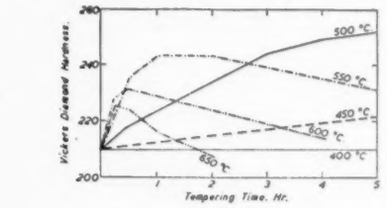


FIG. 2.—CASTING OVH (C 0.3, MN 0.6 AND CU 1.0 PER CENT.). EFFECT OF TEMPERING TEMPERATURE AND TIME ON HARDNESS.

the wall thickness was decreased to ⅜ in. to make pulling more probable. The castings were cut up for examination and the results are summarised in Table II. There was a good deal of unsoundness in the form of elongated cavities in the walls, but there were very few cracks, and although those that occurred were all in the copper-bearing castings, they gave no indication



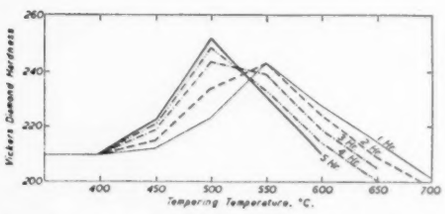


FIG. 3.—CASTING PJT (C 0.3, MN 1.5 AND CU 1.0 PER CENT.). EFFECT OF TEMPERING TEMPERATURE AND TIME ON HARDNESS.

that the copper-bearing steels were specially liable to hot-tearing. The attempt to produce decided hot-tearing at the flanges was not successful in any steel. Dendritic structure and V-segregation were no more marked in the copper-bearing steels than in those free from copper.

Effect of Heat-Treatment

Small specimens of the five copper-bearing steels were first normalised from 900 deg. C. and then reheated at temperatures between 400 and

TABLE IV.—*Mechanical Properties of Steel Castings.*

Mark and approx. composition.	Heat-treatment.	Limit of proportionality. Tons per sq. in.	Yield point.[1] Tons per sq. in.	Maximum load. Tons per sq. in.	Yield ratio. Per cent.	Elongation on 2 in. Per cent.	Reduction of area. Per cent.	Izod impact value. Ft.-lbs.
OUM.	As cast	5.0	11.6	26.7	43	13	13	8
	As cast; T. 4 hr. 500 deg. C.	6.0	12.8	28.3	45	23	30	9
C 0.3 per cent.,	A.C. 900 deg. C.	13.0	18.5	30.9	60	23	34	30
Mn 0.6 per cent.	Furnace-cooled 900 deg. C.	9.0	16.0	28.4	56	30	42	25
	A.C. 900 deg. C.; T. 4 hr. 500 deg. C.	12.0	19.6	32.0	61	23	30	29
	A.C 900 deg. C.; T. 2 hr. 550 deg. C.	14.0	19.4	32.3	60	23	41	24
OVH.	As cast	14.0	21.6	36.4	59	11	13	8
	As cast; T. 4 hr. 500 deg. C.	15.0	27.5	41.4	66	14	22	5
C 0.3 per cent.,	A.C. 900 deg. C.	19.0	23.0	35.0	66	18	25	32
Mn 0.6 per cent.,	Furnace-cooled 900 deg. C.	18.0	22.2	34.2	65	20	27	28
Cu 1.0 per cent.	A.C. 900 deg. C.; T. 4 hr. 500 deg. C.	27.0	32.2	44.4	73	15	24	10
	A.C. 900 deg. C.; T. 2 hr. 550 deg. C.	23.0	29.9	42.7	70	17	29	13
	A.C. 900 deg. C.; T. ½ hr. 600 deg. C.	26.0	31.4	41.0	77	17	29	16
	A.C. 900 deg. C.; T. 1½ hr. 600 deg. C.	20.0	28.0	38.8	72	11	22	18
	A.C. 900 deg. C.; T. 2½ hr. 600 deg. C.	20.0	27.2	38.6	70	21	31	25
OUT.	As cast	7.0	15.6	33.5	47	12	14	5
	As cast; T. 4 hr. 500 deg. C.	9.0	15.7	33.6	47	20	31	5
C 0.3 per cent.,	A.C. 900 deg. C.	21.0	24.5	36.6	67	20	34	23
Mn 1.5 per cent.	Furnace-cooled 900 deg. C.	15.0	20.6	32.8	63	24	34	21
	A.C. 900 deg. C.; T. 4 hr. 500 deg. C.	10.0	25.2	37.2	68	21	35	24
	A.C. 900 deg. C.; T. 2 hr. 550 deg. C.	18.0	24.2	37.0	65	21	36	22
PJT.	As cast	16.0	28.4	39.3	72	4	5	3
	As cast; T. 4 hr. 500 deg. C.[3]	21.0	32.0	—	—	—	—	3
C 0.3 per cent.,	A.C. 900 deg. C.	23.0	30.1	43.4	69	17	30	14
Mn 1.5 per cent.,	Furnace-cooled 900 deg. C.	22.0	25.0	39.4	63	16	25	18
Cu 1.0 per cent.	A.C. 900 deg. C.; T. 4 hr. 500 deg. C.	37.0	38.8	49.2	79	10	20	9
	A.C. 900 deg. C.; T. 2 hr. 550 deg. C.	26.0	34.7	46.6	74	6	15	14
	A.C. 900 deg. C.; T. ½ hr. 600 deg. C.	23.0	33.9	46.2	73	11	19	15
	A.C. 900 deg. C.; R. 1½ hr. 600 deg. C.	24.0	31.7	43.8	72	16	23	16
	A.C. 900 deg. C.; T. 2½ hr. 600 deg. C.	22.0	29.8	42.8	70	19	25	17
OVA.	As cast	10.0	18.4	33.2	55	7	8	7
	As cast; T. 4 hr. 500 deg. C.[2]	9.0	18.2	34.7	52	—	—	6
C 0.3 per cent.,	A.C. 900 deg. C.	17.0	22.1	34.1	65	9	17	21
Mn 0.6 per cent.,	Furnace-cooled 900 deg. C.	12.0	16.9	32.0	53	20	27	20
Cr 0.8 per cent.	A.C. 900 deg. C.; T. 4 hr. 500 deg. C.	16.0	21.0	35.8	59	12	21	18
	A.C. 900 deg. C.; T. 2 hr. 550 deg. C.	17.0	22.3	37.2	60	15	26	17
OVQ.	As cast	13.0	21.9	39.0	56	20	38	10
	As cast; T. 4 hr. 500 deg. C.	21.0	35.6	41.0	87	2	5	6
C 0.3 per cent.,	A.C. 900 deg. C.	—	29.0	41.8	70	22	26	27
Mn 0.6 per cent.,	Furnace-cooled 900 deg. C.	17.0	22.7	40.4	56	21	37	31
Cr 0.8 per cent.,	A.C. 900 deg. C.; T. 4 hr. 500 deg. C.	29.0	38.0	52.4	73	15	26	5
Cu 1.0 per cent.	A.C. 900 deg. C.; T. 2 hr. 550 deg. C.	20.0	31.7	44.7	71	12	26	19
	A.C. 900 deg. C.; T. ½ hr. 600 deg. C.	25.0	33.9	46.0	74	9	14	13
	A.C. 900 deg. C.; T. 1½ hr. 600 deg. C.	23.0	32.2	44.4	73	9	20	18
	A.C. 900 deg. C.; T. 2½ hr. 600 deg. C.	22.0	30.6	44.0	70	16	32	16
OXN.	As cast[2]	9.0	17.7	30.3	58	—	—	11
	As cast; T. 4 hr. 500 deg. C.	9.0	18.0	33.5	54	15	28	9
C 0.3 per cent.,	A.C. 900 deg. C.	13.0	21.1	35.0	60	25	39	36
Mn 0.6 per cent.,	Furnace-cooled 900 deg. C.[2]	14.0	18.6	30.4	61	—	—	34
Ni 1.5 per cent.	A.C. 900 deg. C.; T. 4 hr. 500 deg. C.	15.0	22.4	34.9	64	17	32	35
	A.C. 900 deg. C.; T. 2 hr. 550 deg. C.	15.0	21.6	34.5	63	14	26	25
OXU.	As cast	12.0	23.3	37.0	63	13	15	5
	As cast; T. 4 hr. 500 deg. C.	15.0	27.3	41.5	66	15	23	5
C 0.3 per cent.,	A.C. 900 deg. C.	20.0	27.0	39.1	69	21	36	23
Mn 0.6 per cent.,	Furnace-cooled 900 deg. C.	19.0	24.9	37.8	66	21	34	32
Ni 1.5 per cent.,	A.C. 900 deg. C.; T. 4 hr. 500 deg. C.	27.0	38.0	47.1	81	11	17	14
Cu 1.0 per cent.	A.C. 900 deg. C.; T. 2 hr. 550 deg. C.	22.0	33.6	44.1	76	17	31	23
	A.C. 900 deg. C.; T. ½ hr. 600 deg. C.	21.0	32.0	43.6	73	21	31	26
	A.C. 900 deg. C.; T. 1½ hr. 600 deg. C.	22.0	30.4	41.3	74	17	26	31
	A.C. 900 deg. C.; T. 2½ hr. 600 deg. C.	22.0	30.2	40.3	75	21	34	27
OZZ.	As cast	17.0	28.0	39.4	71	4	5	3
	As cast; T. 4 hr. 500 deg. C.[3]	15.0	27.2	—	—	—	—	4
C 0.3 per cent.,	A.C. 900 deg. C.	13.0	27.1	44.9	60	21	42	22
Mn 0.6 per cent.,	Furnace-cooled 900 deg. C.	16.0	22.7	40.6	56	19	38	25
Cr 0.5 per cent.,	A.C. 900 deg. C.; T. 4 hr. 500 deg. C.	23.0	30.0	46.0	65	17	32	18
Ni 1.5 per cent.	A.C. 900 deg. C.; T. 2 hr. 550 deg. C.	23.0	29.0	44.2	67	20	42	26
OZS.	As cast	22.0	33.7	38.8	87	2	3	3
	As cast; T. 4 hr. 500 deg. C.	24.0	36.0	41.6	87	2	7	2
C 0.3 per cent.,	A.C. 900 deg. C.	16.0	29.6	48.3	61	15	24	11
Mn 0.6 per cent.,	Furnace-cooled 900 deg. C.	23.0	28.5	44.5	64	15	24	22
Cr 0.5 per cent.,	A.C. 900 deg. C.; T. 4 hr. 500 deg. C.	35.0	42.6	56.4	76	13	26	8
Ni 1.5 per cent.,	A.C. 900 deg. C.; T. 2 hr. 550 deg. C.	28.0	38.0	52.4	73	13	24	16
Cu 1.0 per cent.	A.C. 900 deg. C.; T. ½ hr. 600 deg. C.	28.0	37.6	51.9	72	13	19	14
	A.C. 900 deg. C.; T. 1½ hr. 600 deg. C.	24.0	34.6	48.6	71	12	19	18
	A.C. 900 deg. C.; T. 2½ hr. 600 deg. C.	22.0	33.7	47.6	71	12	19	20

[1] Load giving 0.2 per cent. permanent set. [2] Broke outside gauge-length. [3] Broke prematurely at threads.

700 deg. C. for various times up to 6 hrs. The results of hardness tests made on material treated in this way are shown in Figs. 2 to 6 and are very briefly summarised in Table III.

The 1.5 per cent. manganese steel and the nickel-chromium steel were slightly air-hardened in normalising the small specimens, and the apparent effect of temper-hardening was therefore reduced. On the basis of response to temper-hardening the steels may be arranged in the following order:—

	Greatest → Least.
Increase over normalised condition	Cr, C, Ni, Mn, Ni–Cr
" " softened condition..	Cr, Ni–Cr, C, Mn, Ni

TABLE III.—*Effect of Temper-Hardening.*

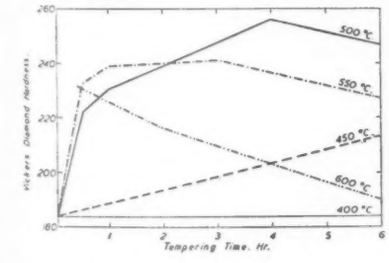
Type of steel: C 0.3 per cent.; Cu 1.0 per cent.	Brinell hardness number.			Increase due to temper-hardening over—	
	As-normalised.	Maximum after temper-hardening.	As-softened 4–6 hr. at 700 deg.	Normalised condition.	Softened condition.
Mn 0.6 per cent.	166	227	166	61	61
Mn 1.5 "	210	252	195	42	57
Cr 0.8 "	184	256	180	72	76
Ni 1.5 "	193	240	184	47	56
Ni 1.5 per cent., Cr 0.5 per cent.	242	268	202	26	66

Mechanical Properties

The mechanical properties of the steels as-cast and after various treatments had been applied to bars 6 in. long by ¾ in. square, cut from the sand-cast ingot (No. 6), are shown in Table IV. Features which are illustrated by the results include the following:—

(1) All the cast steels give the usual response to an annealing treatment and are improved by normalising. Furnace-cooling has a somewhat similar effect to normalising, but gives a slightly softer product.

(2) Tempering the cast steel at 500 deg. C. has little effect in altering the properties of the cast carbon or nickel steels with or without copper. It appears to have a very detrimental effect on the properties of the chromium and nickel-chromium steels with and without copper, causing embrittlement which sometimes led to premature failure of the test-pieces in the screw threads.



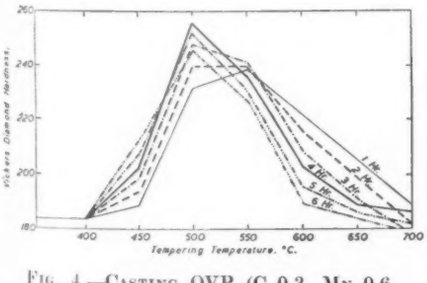


FIG. 4.—CASTING OVP (C 0.3, MN 0.6, CR 0.8 AND CU 1.0 PER CENT.). EFFECT OF TEMPERING TEMPERATURE AND TIME ON HARDNESS.

(3) Tempering the normalised steels had no important effect on the copper-free material, but caused temper-hardening in the copper-bearing steels.

(4) The temper-hardening was accompanied by a considerable increase in the ratio of the yield point to the maximum load, and by a fall in the impact value. Interpolation of the results shows that when temper-hardened to give a tensile strength of 45 tons per sq. in. the steels in order of increasing impact figure are:

Type of steel.	Izod impact figure. Ft.-lbs.				
	C	Mn	Cr	Ni	Ni–Cr
At tensile strength of 45 tons per sq. in.	7	14	16	18	22

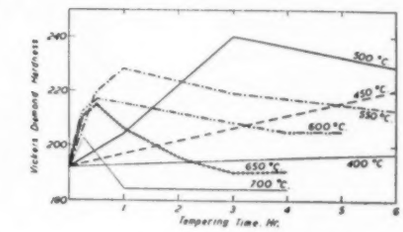
(5) The highest tensile strength and the best combination of properties were obtained in the nickel-chromium-copper steel.

(6) On the basis of the change in tensile strength due to temper-hardening the steels containing copper may be arranged in the following order:

Type of steel.	Tensile strength. Tons per sq. in.				
	Cr	C	Ni–Cr	Ni	Mn
Fully temper-hardened	52.4	44.4	56.4	47.1	49.2
Normalised ..	41.8	35.0	48.3	39.1	43.4
Increase ..	10.6	9.4	8.1	8.0	5.8
Type of steel.	**Cr**	**Ni–Cr**	**C**	**Mn**	**Ni**
Fully temper-hardened	52.4	56.4	44.4	49.2	47.1
Furnace-cooled ..	40.4	44.5	34.2	39.4	37.8
Increase ..	12.0	11.9	10.2	9.8	9.3

The order based on the increase in tensile strength above that of the furnace-cooled steel is the same as was found by hardness tests in the temper-hardened and softened conditions.

The steel in this series which gave the most pronounced response to the temper-hardening treatment was the chromium-copper steel, and confirmatory tests were made on two larger castings of this steel, with the results shown in Table V. In the annealed conditions the casting had a tensile strength exceeding 35 tons per sq. in., with satisfactory ductility as shown by elongation and reduction of area in the tensile test and by the notched-bar impact value. After the castings had been temper-hardened at 500 deg. C. their tensile strength was about 12 tons per sq. in. higher than in the soft condition, but their Izod impact value was reduced to a low figure, *viz.*, 5 to 8 ft.-lbs. Treatment at higher tempering temperatures gave a rather softer material, showing a better combination of properties but with a tensile strength still exceeding 40 tons per sq. in. A comparison of the results of the tests on steels *A* and *B* (Table V) shows that an initial furnace-cooling before the normalising and tempering treatments improves the mechanical properties, including the impact figure.



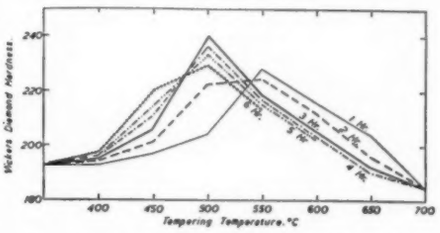


FIG. 5.—CASTING OXU (C 0.3, MN 0.6, NI 1.5 AND CU 1.0 PER CENT.). EFFECT OF TEMPERING TEMPERATURE AND TIME ON HARDNESS.

TABLE V.—*Mechanical Properties of Copper-Chromium Steel Castings Heat-Treated in the Mass.*

	C. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent.	Cu. Per cent.	Cr. Per cent.
Steel *A* ..	0.25	0.29	0.70	0.021	0.031	1.15	0.96
Steel *B* ..	0.25	0.39	0.75	0.011	0.028	0.96	0.95

Mass of air-cooled material: Steel *A*, about 250 lb.; steel *B*, about 50 lb.

Heat-treatment.	Limit of proportionality.	Yield point.[1]	Max. load.	Yield ratio. Per cent.	Elongation on 2 in. Per cent.	Reduction of area. Per cent.	Izod impact value. Ft.-lbs.	Brinell hardness number.
	Tons per sq. in.							
Steel A.								
As cast	14	23.5	42.3	56	12	17	5	200
Furnace-cooled from 950 deg. C. ..	16	20.0	36.0	56	21	31	19	163
A.C. 950 deg. C., then T. 4 hr. at 500 deg. C.	29	34.6	48.0	72	8	19	6	241
A.C. 950 deg. C., then T. 2 hr. at 600 deg. C.	19	29.6	44.1	67	15	19	20	213
A.C. 950 deg. C., then T. 1 hr. at 650 deg. C.	14	26.4	41.8	63	12	19	26	207
A.C. 950 deg. C., then T. 1 hr. at 700 deg. C.	17	24.4	40.8	60	20	31	30	190
Steel B.								
As cast	14	24.8	39.7	62	4	7	3	200
Furnace-cooled from 950 deg. C. ..	16	18.9	37.3	51	25	39	19	167
A.C. 950 deg. C., then T. 4 hr. at 500 deg. C.	28	33.0	50.0	66	20	38	7	246
Furnace-cooled 950 deg. C., A. C. 900 deg. C., then T. 4 hr. at 500 deg. C. ..	30	36.0	50.0	72	12	17	18	244
Furnace-cooled 950 deg. C., A.C. 900 deg. C., then T. 2 hr. at 600 deg. C. ..	18	28.0	45.6	60	23	42	31	208
Furnace-cooled 950 deg. C., A.C. 900 deg. C., then T. 1 hr. at 650 deg. C. ..	15	27.0	44.1	60	16	25	37	201
Furnace-cooled 950 deg. C., A.C. 900 deg. C., then T. 1 hr. at 700 deg. C. ..	16	24.4	41.1	59	16	26	49	191

[1] Load giving 0.2 per cent. permanent set.

(*Concluded on page 348.*)

■2

Notes from the Branches

Scottish Branch.—The opening meeting of the session of the Scottish Branch of the Institute of British Foundrymen was held in the Royal Technical College, Glasgow, last month, Mr. Evan J. Ross (the retiring President) at first occupying the chair. In opening, Mr. Ross said that at the beginning of a new session one looked forward to something new, and he hoped to gain new knowledge. In his own case he was perhaps looking forward and hoping for an easier year. His year of office, which was just terminating, had been one of great joy. He had rather feared that he would not be able to carry on the work as it should be done, but the hearty co-operation and assistance of the Secretary and members of the Council had made his task light and pleasant.

Mr. Ross expressed regret that the new President, Mr. R. Ballantine, was unable to be with them because of illness. He asked the members to accord to the new President the same hearty support and assistance as they had given to himself. There was no more energetic and enthusiastic member of the Council than Mr. Ballantine, and it was suggested that the meeting send him a message of sympathy and wishes for a speedy recovery from his illness.

MR. N. ERSKINE (Senior Vice-President) then took the chair, which, he said, Mr. Ross had vacated after a very successful term of office. He pointed out that the Branch-Presidency required the ability to promote and stimulate discussion, and he thought all would agree that Mr. Ross had done this very well.

The SECRETARY then announced that the Principal of Stow College had suggested that the Sir Archibald McInnes Shaw prizes should be presented to the successful candidates at that meeting. Mr. E. Ross presented the prizes to four successful candidates.

The CHAIRMAN then called on Mr. A. M. Campbell to read his Paper on "Gating and Feeding of Castings," for which he was awarded the John Surtees Gold Medal.

At the conclusion of the meeting the members and their ladies met in the Cadora Restaurant for the annual opening social evening, the proceedings including whist and an entertainment provided by a concert party from G. & J. Weir's foundry. Mr. H. Winterton acted as M.C., Mr. N. Erskine presided, and Miss Ballantine presented the prizes to the successful whist players. Mr. D. Sharpe proposed a vote of thanks to Miss Ballantine, and asked her to convey to her father the good wishes of the members for his speedy return to health.

East Anglian Section.—The 1938-39 session of the East Anglian Section of the Institute of British Foundrymen was inaugurated by a visit last month to the Foxhall Works of E. R. & F. Turner, Limited, Ipswich. Some 30 members of the East Anglian Section and London Branch attended. In the unavoidable absence of Mr. A. Leggett (managing director), Mr. Percy Leggett and Mr. D. Guthrie acted as guides.

The firm has long been noted for the manufacture of flour-milling machinery, a specialised production being chilled rolls. Naturally the methods employed in the founding of these rolls proved of very great interest, and it was learned that special rolls were made also for the sugar, rubber and paper industries.

Another feature which attracted attention was the aluminium pressure die-casting machine. Armature stampings mounted on a shaft were enclosed in a die into which molten aluminium was injected under pressure. By this means the aluminium penetrated all the winding holes and slots and a completely wound armature resulted in a matter of seconds, effecting a tremendous time saving over winding and brazing by hand. Incidently, the production of Bull electric motors is another of the firm's activities.

The site of the Foxhall Works comprises a considerable area, occupied until this year by the foundry alone. Now, however, a new office block and workshops have been erected. These are of the most spacious and up-to-date design, and eventually the works operating in other parts of the town will be transferred to the new buildings, so that production will be completed on the one site, with ample room for expansion. The construction of the new works and the removal of the machinery from the old during this year serves as an appropriate celebration for a century of progress, and marks the hundredth anniversary of the firm's foundation.

Following the works visit, a general meeting of the Section was held in the early evening in the Lecture Hall of the Central Library, Ipswich, when Dr. A. B. Everest presented the Report of the Cast Iron Sub-Committee.

Later the members adjourned to the Crown and Anchor Hotel for a social evening, the proceedings being opened by Mr. C. C. Booth (President of the London Branch) inducting Colonel C. Portway into the chair. In the course of a short address COLONEL PORTWAY made a plea for increased membership, deeming the figure of 2,250 as low, considering there were 3,000 ironfoundries. He then referred to such benefits as the Branch meetings, the publication of Papers, the Proceedings (which he described as the best reference book in foundry practice), works visits and re-employment services. After commenting on the collaboration of the Institute with the British Standards Institution, he finally dealt with the incidence of the revised rules.

A vote of thanks was accorded to Colonel Portway on the proposition of Mr. C. H. Kain, seconded by Dr. Everest.

Fraudulent Merchandise Marks

An interesting section of the Patent (International Conventions) Act, 1938, amends a provision of the Merchandise Marks Act, 1887, which measure concerns the question of fraudulent marks on merchandise. Various practices are made illegal by that Act, but this brief explanation will be confined to the alterations made by the 1938 Act.

If a person applies any false description or trade mark to goods it is an offence, and the amendment really concerns the meaning given to the term "applying." The sub-section of the 1887 Act lays down that a person is deemed to apply a trade mark or mark or trade description to goods who "uses a trade mark or mark or trade description in any manner calculated to lead to the belief that the goods in connection with which it is used are designated or described by that trade mark or mark or trade description."

Under the law prior to this Act it had been held that, for a false trade description—the term includes a false description as to the origin of the goods—to be an offence, the description must be used in relation to the actual goods. The 1938 Act now makes clear that the law in future will apply to a trade description or mark or trade mark appearing in any sign, advertisement, invoice, business letter, business paper or other commercial communication, as well as upon or in connection with the actual goods.

It might be useful to note that the Merchandise Marks Acts define the term "trade description" as meaning any description, statement or other indication, direct or indirect, as to the number, quantity, measure, gauge or weight of any goods; as to the place or country in which any goods were made or produced; to the mode of manufacturing or producing; to the material of which any goods are composed, and as to any goods being the subject of an existing patent, privilege or copyright.

Copper-Steel Castings

(*Concluded from page* 347.)

The investigation described in this Paper was initiated by the Metallurgy Research Board of the Department of Scientific and Industrial Research, and was subsequently carried on in association with the Steel Castings Research

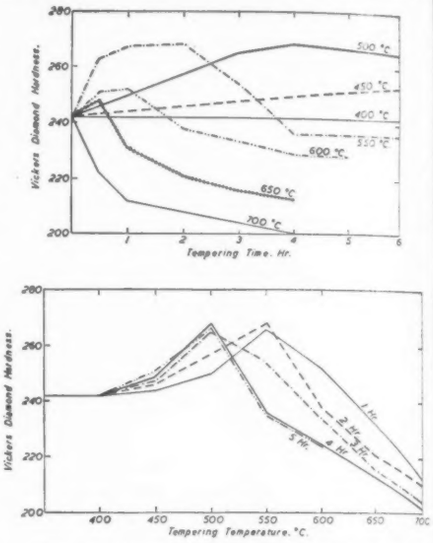


FIG. 6.—CASTING OZS (C 0.3, MN 0.6, NI 1.5, CR 0.5 AND CU 1.0 PER CENT.). EFFECT OF TEMPERING TEMPERATURE AND TIME ON HARDNESS.

Committee, to the members of which (especially to Mr. J. E. Mercer who supplied the larger copper-chromium steel castings) the author desires to express his thanks.

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7 R. Harrison: Journal of the Iron and Steel Institute, 1938, No. 1.

Catalogue Received

Stoppers and Nozzles. The reviewer knows of no textbook which gives better, more reliable or concise information on the tricky operation of stopper and nozzle setting than a catalogue just published by the Morgan Crucible Company, Limited, of Battersea Works, London, S.W.11. It is a long time since the reviewer actually supervised this job, but twenty years ago it was the fashion to use either a plumbago nozzle and a fireclay stopper end or *vice versa*. It was rather a confession of weakness in technique, for now it is quite usual to see plumbago to plumbago assemblies. Eight hints are set out, but, if a further one is needed, it is suggested that where a ladle is kept waiting and so cools down, a further adjustment just before tapping is desirable, as contraction may allow the metal to percolate between the stopper end and the nozzle, and cause, at the minimum, a "sticky" pour. The latest device at the immediate post-war period is shown on page 5—S. 227—and was then known as the Vickers type, but the screwed types were, it is thought, not then available. These seem thoroughly practical and would be the subject of an early trial, if the reviewer ever returned to steelmaking and encountered trouble. The "blob" of refractory used to cause trouble on occasion! As one never knows when a spell of bad luck is going to overtake the harassed steelmaker, it is suggested that this catalogue be procured and the hints therein thoroughly mastered.

Effect of Fluxes on Cupola Linings*

By C. K. DONOHO and J. T. MACKENZIE

Introduction

It has been estimated[1] that the cupola furnace is responsible for the consumption of 3 to 4 per cent. of all refractory materials consumed in the United States. Because this amount represents a large volume of firebrick, special shapes, and silica stone, considerable study of the importance of the various factors determining the life of cupola linings is warranted.

Cupola linings are simultaneously subjected to three types of destructive influences[2]: (1) *Physical:* Maximum temperatures in the cupola melting zone are generally estimated at slightly over 1,650 deg. C., which is often sufficient to cause softening or actual melting of refractories. Temperature changes are sharp enough to cause a certain amount of spalling. (2) *Mechanical:* Linings are subjected to wear and abrasion by

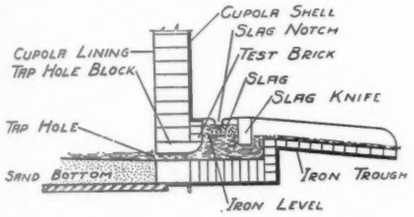

FIG. 1.—COMPARATIVE TEST FOR RATING FIREBRICK.

the descent of the solid charges of iron and coke and by the impingement of solid particles carried upward by the blast. (3) *Chemical:* Various constituents of the charges and combustion products react chemically with the lining, causing solution of the refractories or at least softening and lowering of melting points so that the physical and mechanical attack is augmented.

That section of the cupola lining which extends from the tuyères upward two or three feet constitutes the melting zone. It is this area only which is subject to severe attack by all three types of influences. The hearth, below the tuyères, must withstand the temperature of

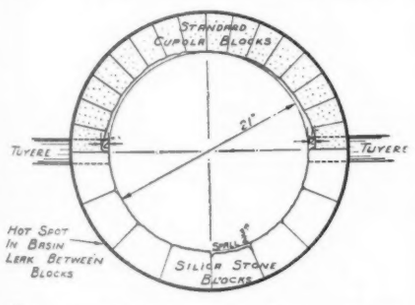

FIG. 2.—COMPARISON OF SILICA STONE BLOCKS WITH STANDARD CUPOLA BRICKS.

Cross-section, 12 in. above tuyeres. *Twelve charges* (lbs.): 12½ coke, 4 dolomite, 100 electric furnace pig. *Three charges* (lbs.): 10 coke, 4 dolomite, 100 rusty steel scrap, 50 pipe scrap.

molten iron and some chemical action. The stack, above the melting zone, must withstand severe abrasion but no extreme heat or chemical action. Therefore it is only in the melting zone that the lining must be partially renewed or patched after each heat. A new cupola is usually lined for the first heat with standard cupola blocks from the bottom of the hearth to just above the charging door, with, of course, openings for tuyères, tap hole, and slag hole. After each subsequent heat, the melting zone only is patched to the original dimension of the lining inasmuch as the rest of the lining lasts indefinitely.

In standard practice at the writers' plant, for patching the melting zone of the cupolas after each heat, frozen slag, coke and iron adhering to the walls around the tuyères and above are chipped out until a clean firebrick surface is exposed. Nine-inch straight and split firebricks are carefully laid in as required, using a thin slurry behind the brick and in the joints. The firebricks used are so-called "overburned" brick made by the stiff-mud repress process, and the slurry is composed of one part finely ground firebrick grog to one part plastic fireclay, mixed with water. A local fireclay found to be satisfactory contains about 90 per cent. silica. This clay is sufficiently refractory and is also surprisingly plastic for a clay of this composition.

The patching approximately restores the straight line of the cupola shaft but is not allowed to encroach on the cupola area. The damp patching is dried slowly by a wood fire before blowing in.

In selecting firebrick for melting-zone service, three principal properties must be considered: density, toughness, and spalling resistance. A refractory which possesses one of these to an extreme degree will probably not be the most successful, but the cupola brick must possess all these properties in the correct proportion or "strike a happy medium." In considering density, it is well to qualify this property. In a dense firebrick, the apparent porosity, or percentage of open pores, usually runs low. This low porosity is important, but it is also essential that the pores be small and that the brick possess a low permeability. The size of the pores is particularly important in determining the degree of chemical attack by slags.

Testing Refractories for Cupola Service

A simple comparative test has proved effective for roughly rating the suitability of refractory material for melting-zone service in the cupola (see Fig. 1 and Table I). A 9-in. straight brick of the material to be tested is placed just above the tap hole of a 72-in. by 102-in. link-shaped cupola used in production. These cupolas normally run for 8 hrs. under fairly uniform conditions with an output of 20 to 30 tons per hr. The molten metal and slag flow continuously from the tap hole and pass over the exposed surface of the test brick for the complete 8-hr. run. In this test, the brick is subjected to approximately the same physical and chemical attack which would be encountered in service although the mechanical attack is negligible. The depth of cutting the brick is measured and compared with standard brick having known service qualifications. Samples of firebrick of unknown service properties are always tested in this manner before attempting to use them in the cupola lining. So far, in every case where the brick tested stood up as well as standard brick, these bricks have given satisfactory melting zone service.

A more thorough test for lining materials of unknown properties by use of a small test cupola has been discussed.[3] Fig. 2, which is self-explanatory, shows a recent test of this type, using blocks cut from a natural silica rock and standard fireclay blocks.

Effect of Fluxes—Service Tests

Test Series No. 1.

Standard cupola practice at this plant involves the use of locally obtained dolomite as a flux. This is added with the coke in the charge to the amount of approximately 3 per cent. of the metal charge, coke being about 10 per cent. of the metal charge. By this practice, a slag of good fluidity is produced which has no severe cutting action on refractories.

During the past year, the supply of dolomite was shut off for a short period and limestone was tried as a substitute. Analyses of the two fluxing materials and slags resulting are given in Table II. The limestone slag seemed less fluid than the dolomite slag and often appeared foamy, sometimes causing trouble by rising up in the cupola until the tuyères were partially blocked. The cupola lining, which was of the standard firebrick previously described, was more severely attacked when limestone was used as the flux, as the data in Table III will show.

The number of brick used to patch the lining to the original dimensions after each heat was

TABLE I.—*Data on Firebrick Subjected to Comparative Test.*

	A.	B.	C.	D.	E.
SiO_2	56.00	60.00	60.00	63.5	64.5
Al_2O_3	38.29	34.10	31.96	29.1	27.0
Fe_2O_3	1.85	1.70	2.81	2.8	2.8
TiO_2	1.70	1.58	1.49	1.6	1.4
MgO and CaO	0.68	0.80	0.98	1.1	1.10
Alkalis	1.39	1.40	1.93	1.9	2.98
Fusion point (P.C.E.)	33	32–32½	31	30–31	29
,, ,, (deg. C.)	1,720	1,700–1,722	1,680	1,650–1,680	1,640
Modulus of rupture (lb./sq. in.)	1,127	1,700	1,857	2,100	2,150
Absorption (per cent.)	14.20	10.80	8.70	5.8	2.9
Apparent porosity	28.2	21.5	15.9	12.7	5.6
Dry weight	7.25	7.50	7.50	7.7	7.7
Water-dip spalling for 20 per cent. loss	27+	15	10	9.10	5

TABLE II.—*Analyses of Two Fluxes and Resulting Cupola Slags.*

	Limestone.	Dolomite.	Limestone slag.	Dolomite slag.
CaO	50.80	30.95	24.35	15.04
MgO	1.17	20.55	0.95	11.60
SiO_2	2.60	1.32	45.88	47.05
Iron oxide	0.66	0.39	6.80	3.15
R_2O_3	0.80	0.33	*22.02	*23.16
Loss on ignition	43.97	46.46	—	—

* Largely Al_2O_3.

TABLE III.—*Effect of Flux Used on Refractories Consumed. (72-in. by 102-in. Cupola)s.*

		Flux.	
		Limestone.	Dolomite.
Total number of heats		20	20
No. of heats requiring	150–200 9-in. equivalents	—	2
	200–250 ,, ,,	—	10
	250–300 ,, ,,	5	6
	300–350 ,, ,,	7	2
	350–400 ,, ,,	4	—
	400–450 ,, ,,	1	—
	450–500 ,, ,,	2	—
	Over 500	1	—
Average No. 9-in. equivalents required per heat		345	220

* Extracted from the Bulletin of the American Ceramic Society 17, No. 8, 1938.

[1] J. D. Sullivan. "Notes on Some Foundry Refractories," Trans. Amer. Foundrymen's Assn., **44**, 255 (1932).

[2] J. T. MacKenzie. "Effect of Variations in Cupola Practice on the Life of the Refractory Blocks," Jour. Amer. Ceram. Soc., **8**, [11], 720–33 (1925).

[3] J. T. MacKenzie, "Use of a Small Cupola in Testing Cupola Linings," Jour. Amer. Ceram. Soc., **12**, [7], 443–46 (1929).

recorded and is here expressed as 9-in. equivalents, which is the sum of the number of 9-in. straights and one-half the number of 9-in. splits required. Table III gives the data for the 72-in. by 102-in. link-shaped cupolas which were melting approximately 25 tons per hr. for an 8-hr. shift. There was little difference in the mixes charged, coke ratios, blast pressures, etc., from one heat to another during this period, so the difference in amount of patching as shown in Table III may be reasonably attributed to the flux used.

Test Series No. 2.

During the same period, records were kept on patching 60-in. diameter cupolas melting approximately 11 tons per hr. for a 16-hr. heat. Owing to the length of the heat, lining attack was more severe and there was difficulty in making the linings last for the entire heat. In order to increase the fluidity of the slag while dolomite flux was not available, some heats were run using 15 per cent. fluorspar mixed with the limestone as a flux. Results are shown in Table IV.

TABLE IV.—*Effect of Flux Used on Refractories Consumed (60-in. Cupolas).*

	Flux.		
	Limestone.	Limestone and 15 per cent. CaF_2	Dolomite.
Total number of heats	14	12	8
No. of heats requiring: 400–500 9-in. equivalents	9	8	8
No. of heats requiring: 500–600 „ „	2	4	—
No. of heats requiring: 600–700 „ „	1	—	—
No. of heats requiring: Over 700	2	—	—
Average No. of 9-in. equivalents required per heat	522	483	442

Observations less quantitatively mensurable than brick consumption show even more definitely the relative attack when using these three fluxes. When limestone alone was the flux used, about one-half of the heats showed lining attack such that the cupola shell became red hot over the areas of most severe attack. In the two cases where more than 700 9-in. equivalents were consumed, the shell was melted through before the heat was completed. When fluorspar was used with the limestone, " hot spots " showed up in only two heats. During the eight heats when dolomite was used there was no lining trouble whatsoever.

Test Series No. 3.

A pair of 42-in. cupolas, running alternate 8-hr. heats at practically their maximum capacity of 7 tons per hr., were selected as the instruments for testing the action of sodium carbonate or Purite on cupola linings. The

TABLE V.—*Effect of Flux Used on Refractories Consumed (42-in. Cupolas).*

Heat No.	Flux used.	Refractories consumed (9-in. equivalents).	
1	Dolomite	188	
2	„	168	av. 180
3	„	185	
4	Dolomite + 5 per cent. Purite	120	
5	„ „ „	125	av. 121
6	„ „ „	118	
7	Dolomite + 10 per cent. Purite	178	178

metal charges were composed of pig-iron plus 40 per cent. steel scrap. This high percentage of steel as well as the high melting rate caused the attack of linings to be unusually severe because the steel scrap is more easily oxidised than the pig-iron containing higher percentage of carbon and silicon. Table V shows a record of seven consecutive heats with three fluxes.

" Hot spots " on the cupolas occurred in two of the three heats using dolomite alone as a flux and in the heat using 10 per cent. of Purite with the dolomite, while there was no lining trouble when 5 per cent. of Purite was used. The slag analyses showed 9 per cent. of iron oxide in the slag from heat No. 2 and only 6 per cent. pig-iron oxide in the slag from heat No. 5.

Discussion of Results

Numerous investigators[4] have referred to the violent attack of cupola refractories by iron oxide in the melting zone. Any factor of cupola operation which causes undue oxidation of the metal would be expected to increase the attack of the lining.

A viscous, high-melting slag is one factor which often contributes to excessive metal oxidation. Such a slag is easily solidified by the air blast from the tuyères, causing " bridging " in or below the melting zone. Air passages are restricted with consequent formation of local high-velocity jets of air which may violently oxidise the melting metal or may even act directly against the hot lining. Viscous slag is also more likely to contain localised concentrations of corrosive constituents which in a free-flowing slag would be diluted by more thorough mixing.

Stiffness of the slag may therefore increase the attack of cupola linings (1) by causing an increase in iron-oxide content of the slag, (2) by deflecting the air blast directly against the lining, and (3) by preventing mixing of the slag and dilution of corrosive constituents.

Test series No. 1 indicates definitely that some magnesia in a limestone-type cupola flux is distinctly beneficial to the life of the refractory lining. Observations indicate that this effect is due to increased fluidity of the slag.

Test series No. 2 shows that fluorspar, although itself corrosive to refractories, may be used to increase lining life by mixing with limestone to increase the fluidity of the slag.

Test series No. 3 shows how sodium carbonate, as claimed by Evans,[5] may be used as a small percentage of the flux to decrease attack of the lining. That a high percentage of sodium carbonate may cause appreciable chemical attack of the lining is evidenced by the last heat shown.

These results indicate that deleterious chemical action of fluxes themselves on cupola linings may be exaggerated and that fluidity of slag at operating temperatures is an item of primary importance. Users of refractories for cupola linings should carefully investigate operating conditions before condemning a refractory for melting zone service.

Iron-Silver Alloys

Contrary to popular belief, silver does alloy with iron, according to Fink and de Marchi of Columbia University. A number of experiments with the new alloys were described in a Paper presented before the Electrochemical Society meeting at Rochester. Outstanding characteristics of the alloys are:—(1) Maximum amount of silver dissolved in the ferrite grains is between 0.5 and 1.0 per cent.; (2) behaviour of the alloys is very similar to that of iron-copper alloys; (3) small amounts of silver definitely improve the resistance of the iron to the corrosive action of 10 per cent. hydrochloric acid and 30 per cent. acetic acid. In addition, ohmic resistance measurements prove beyond doubt that a true alloy bond does exist. The proof of a positive alloy bond between iron and silver explains the good adhesion of electrodepositions, shows that a copper undercoating is unnecessary, and opens up the possibility of iron-to-silver welding. To prepare the alloys it was necessary to mix thoroughly exact quantities of iron powder and silver crystals, submit them to 41 tons pressure and sinter for 4 hrs. at 950 deg. C., in an atmosphere of hydrogen. The resulting bars were then cold-rolled and heat-treated before experimentation.

[4] A. H. Kuechler, " Influence of Fe_2O_3 and TiO_2 on Pure Clays," Jour. Amer. Ceram. Soc., **9**, [2], 105–106 (1926).

[5] G. S. Evans, " Sodium Carbonate Compounds Affect Refractory Linings," " Foundry," **55**, 632–34 (1927); " Ceram. Abs.," **6**, [11], 522 (1927).

American Notes

FROM OUR NEW YORK CORRESPONDENT.

The experience of the Garfield Manufacturing Company of Garfield, New Jersey, with cast-iron die-blocks used in moulding plastics is of more than local interest, according to a report released by the Climax Molybdenum Company. The uses of cold moulded plastics are varied. Due to exceptional insulating qualities, there is wide application in the electrical field, whilst the heat-resistance property of plastics is utilised in knobs and handles for cooking utensils. Other uses range from cork tops to third rail insulators.

The basic manufacturing process is the same for all parts, regardless of ultimate service, according to the report. The ingredients, with asbestos as the base, are mixed and kneaded until powder of proper consistency for moulding is prepared. The powder is placed in moulds and pressed into form by hydraulic presses of capacities rated from 5 to 500 tons. The formed article is then cured for a period determined by the properties required for its ultimate service.

The cold moulding method employed, while it permits a high rate of production, imposes strict requirements on materials from which various parts of moulding equipment are made. They must be tough and hard, capable of standing high pressures and of maintaining microscopic tolerances over long periods of continuous service. Dies to meet these requirements were made from a high-grade tool steel and the blocks from a nickel-chromium-molybdenum cast iron.

The following is the analysis range of the die-blocks, cast from high-duty cast iron:—T.C, 3.00 to 3.10; C.C, 0.60 to 0.70; Si, 2.20 to 2.40; Mn, 0.80 to 0.90; P (max.), 0.10; S (max.), 0.08; Ni, 0.70 to 0.80; Cr, 0.20 to 0.30; and Mo, 0.50 to 0.60 per cent.

The iron, it is stated, develops very good physical properties in the as-cast condition, the tensile strength varying between 22 and 30 tons per sq. in. Transverse tests made on standard A.S.T.M. 1.2-in. dia. test-bars broken on 18-in. centres, show transverse strengths varying from 2,600 to 3,600 lbs. The hardness range is from 240 to 260 B.H.N.

The blocks have qualities in addition to their physical properties that add considerably to their serviceability in this particular case. They are quite large and massive, being from 4 to 7 in. thick and 18 in. to 2 ft. sq. The slot is formed by coring. In spite of the thickness of the section, the structure of the blocks is very uniform and free from porosity or other casting defects.

The iron is very fine-grained, and its hardness is uniform, factors which are quite important with regard to service. The inner surface of the cored section is finished to almost a mirror polish and to very close tolerances. Both the finish and the tolerances must be maintained, first because the side of the die-block often forms the side of the article to be moulded, and, secondly, because any space between the upper die and the block would allow a leakage of plastic that would ruin the moulded part. The iron must be highly resistant to the wearing action of the moving die, working without lubrication at what practically amounts to an interference fit.

The use of this iron has proved advantageous to both the plastic manufacturer and the foundry that makes it. In the former case trouble from die-block breakage has been eliminated, and so has the waste involved in machining blocks and then finding them defective. Die life in terms of the number of acceptable parts produced has been lengthened. The foundry finds it possible by systematic and close metallurgical control to duplicate results consistently. That is, the blocks are always uniform with respect to structure and physical properties. Consequently production is not delayed by the necessity of replacing defective or rejected castings.

A General Engineering Foundry

By F. WHITEHOUSE

(*Concluded from page* 323.)

Much of the success of this green-sand practice is due to the kind of sand used, and although there is no daily scientific control, a great deal of attention is paid to proper preparation. Figs. 18 and 19 are photomicrographs of the new sand used, and it is certainly true that departure from this supply or its quality quickly shows itself in the quality of the castings. An attempt is, of course, being made to garner the fruits of practical experience, and analyse and tabulate data so as to serve as standards for future reference. The present mixing of sand is approximately 40 per cent. new sand, 40 per cent. old sand, and 10 per cent. coal dust. This is mixed entirely by hand.

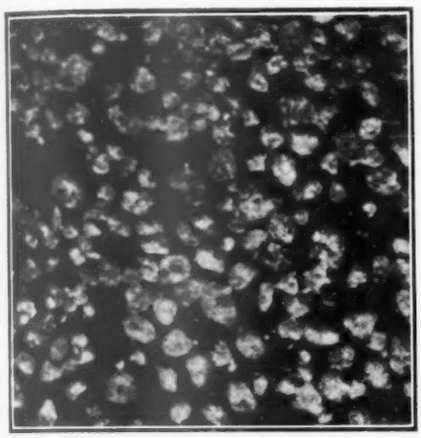

FIG. 18.—NEW SAND AS RECEIVED. × 25.

Figs. 20 and 21 illustrate castings made in green sand for which strict sand control is imperative, and something like a semi-synthetic sand is used for the purpose. It is, of course, only the outside, *i.e.*, the mould, which is of green sand; nevertheless, the problem of running the thousands of needles on a 9-ft. air heater is no light one, more particularly since these castings are of special heat-resisting iron. These castings are only 6 mm. thick, and the moulds are made on a special jolt-strip machine. They represent a good example of what foundry engineering combined with metallurgical development and scientific sand control can attain.

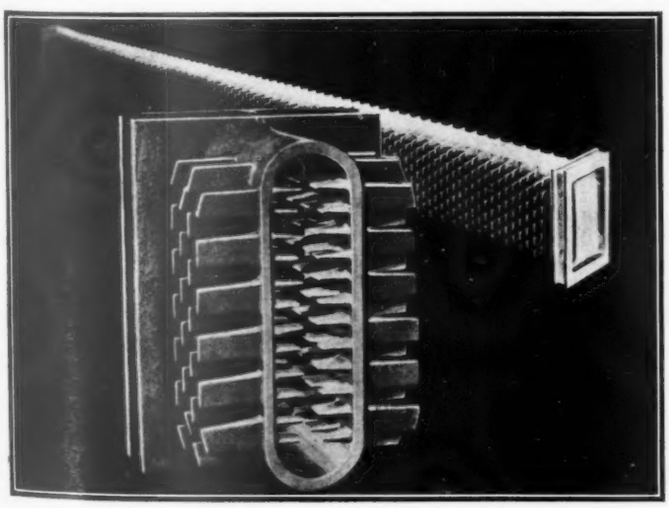

FIG. 20.—NEEDLE AIR-HEATER CASTINGS.

Dry-Sand Practice

In dry-sand practice it is proposed to give only one illustration of what may be regarded as a short cut in manufacture. Fig. 22 shows a high-chromium heat-resisting cast-iron retort, which must be cast vertically and contain as few studs or chaplets as possible. Originally the order was for four off. Fig. 23 shows the pattern and the type of box provided. The real problem was in the making of the core, which is, it will be observed, long, wide and thin. Fig. 24 shows the core ready for the mould. The special provision made here was in providing a core-box and a core-iron. The core-box was made by casting a trough of the appropriate length, width and depth "open sand." It was finished by first machining the edges of the trough and later strickling a bed of the correct shape into it, this being dried and then tarred. The bottom half of the core-box is then ready for use.

The core-iron was made by selecting a core-barrel of the requisite length, actually 16 ft., which tapered from 10 in. to 9 in. in diameter. The end of this barrel was blanked off and provision made for a screwed lifting plug to be fitted into the blank end. Further, a keyway, 1 in. wide and ½ in. deep, was machined down the length of the core-barrel. Core-plates to shape and having prods 1 ft. long, were now cast "open sand"; in the hole in the plate which was to slip over the core-barrel there was also cast a keyway, so that each plate could be set in correct relation to the other by driving a key in the keyway in the core-barrel and the keyway in the core-plate. The prods in one core-plate rested on the plate of the next core-plate. The principle can be clearly seen in Fig. 25. In order to make sure that these plates did not slip off the barrel, a cotter hole was cut near the blank end of the core-barrel, and a cotter bar pushed through this, the bottom core-plate resting on this cotter. Thus, there is a core-iron adequately supported by a cotter when in the vertical position, and adequately aligned by means of keyways in core-plate and barrel.

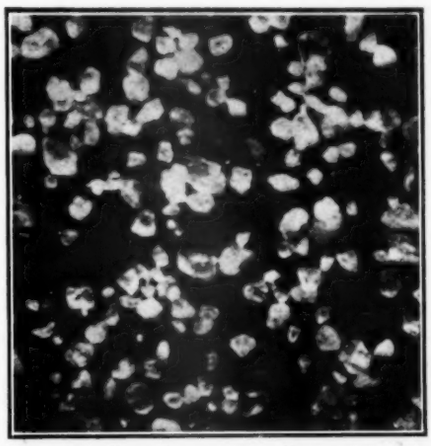

FIG. 19.—NEW SAND WITH CLAY REMOVED. × 25.

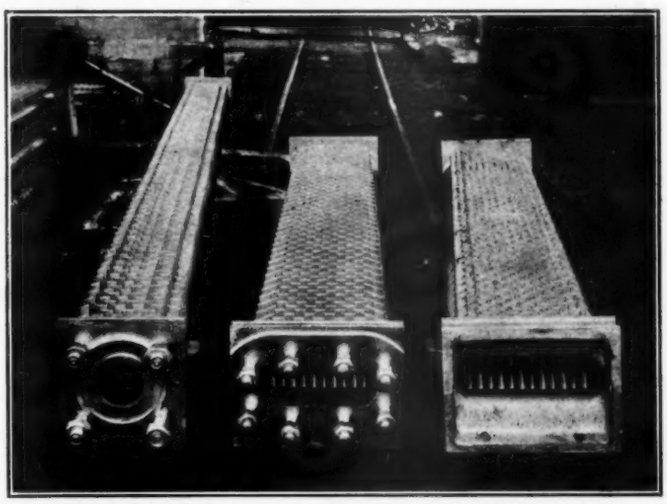

FIG. 21.—AIR-HEATER AND ECONOMISER CASTINGS, MADE IN GREEN SAND.

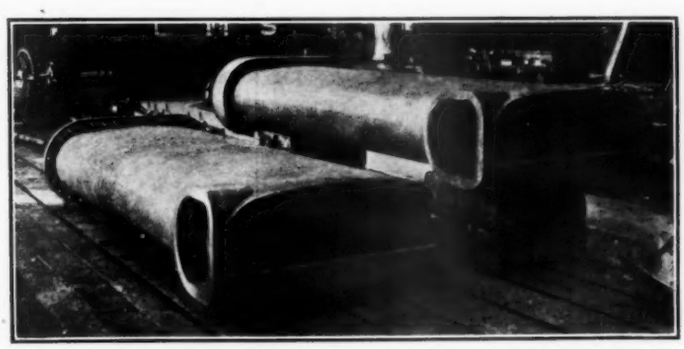

FIG. 22.—HIGH-CHROMIUM HEAT-RESISTING CAST RETORTS, WEIGHING APPROX. 10 TONS.

The method of making the core is to line the trough with about 3 in. of loam, drop the core-iron on to this, fill in the centre with coke, and finish off with a further layer of loam. The manner of supporting the core in the mould is to have an iron packing which reaches from the

bottom plate of the box to the bottom face of the mould. On this is rested a cast-iron stud, machined and grooved, and approximately 3 in. in diameter. The arrangement on the core is to take out from the blank end the screwed plug, which is used for lifting the core about, and in its place to screw a short plug which comes level

FIG. 23.—PATTERN FOR RETORT SET IN BOTTOM BOX.

with the bottom face of the core. To prevent the core twisting, a hooked bolt is passed through the mouthpiece core into the main core, and tied back to the outside of the box. The upper end of the core is located by means of chaplets in the

FIG. 24.—RETORT CORE READY TO DROP INTO MOULD.

head. The casting is run from the bottom until a quarter full, and then the top gates are released. The casting is 3 in. thick and weighs 10 tons. Figs. 26, 27 and 28 depict a three-way valve and its manufacture. Probably the only feature of note is the type of core-iron provided.

Loam

Fig. 29 reveals a problem in putting a spiral rifling on a loam core. Formerly this rifling was of mild steel and fastened separately to the casting. This particular casting was an experiment in making the rifle a part of the casting. It ought to be emphasised that the rifling did not demand to be to $\frac{1}{16}$ in. accurate. The manner of procedure is fairly obvious from the illustration. A core was struck which had a thickness of some 3 in. of loam. This was allowed to air-dry and the rifling then marked off by means of a piece of string and some centre lines, and cut out. The strickles marked A were then used to make the actual shape of the rifling.

Figs. 30 to 33 show an acid pan, ten of which were to be made. The branch had to be cored with a $2\frac{1}{2}$-in. dia. core. This presented the real problem. An auxiliary problem was in trying to save as much of the mould as possible for repeated use. As will be seen, the branch pattern was in two pieces, one-half to be drawn within the mould, and one-half to be taken from outside the rings. The brackets were put in by means of cores. The brickwork was preserved by the use of cast-iron frames, the idea being to renew

FIG. 25.—CORE-BOX AND CORE-IRON FOR RETORT CORE.

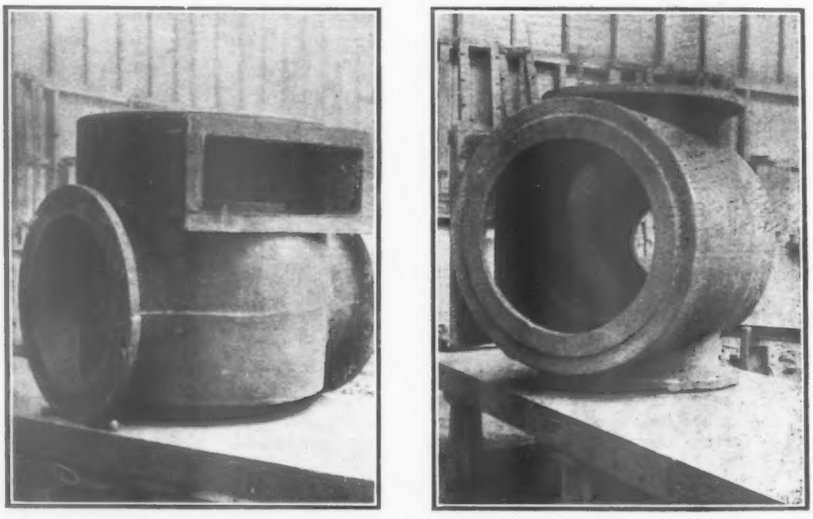

FIG. 26.—TWO VIEWS OF A THREE-WAY VALVE CASTING.

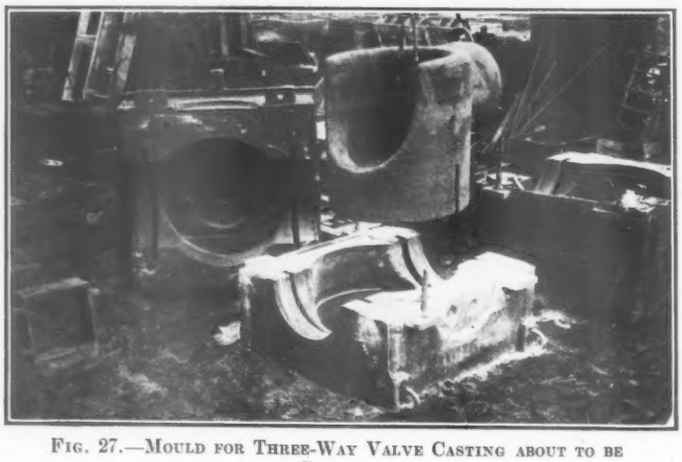

FIG. 27.—MOULD FOR THREE-WAY VALVE CASTING ABOUT TO BE CLOSED.

only that part of the mould which had to be destroyed in taking out the casting. The question of locating the branch core was a more difficult problem. It needed to be secure in the centre, and to be accurately set on the outside. The outside was catered for by having a hole cut in the loam rings where the branch came. A taper print was put on the end of the branch, and a cake core was made to fit in this print and also locate the centre core.

The long branch core was put in from the outside, after the mould had been assembled. Special provision for locating this branch core was made on the top half of the mould. The branch core was made on a core-barrel which had a special tapered end. This end fitted into a bar fixed in the top half of the mould, and containing a hole of the same size and taper as the end of the branch core-barrel. This special bar was fastened to the top half of the mould through the plate on which the domed part of the upper half of the mould is built. The bar slips through the hole left by the spindle and is fastened by means of a cotter.

In order to ensure that the branch core, which is some 5 ft. in length and only 2½ in. in diameter, shall not distort, a special chaplet had to be made to locate it in the centre of its length. This chaplet took the form of a cast-iron ring with a 2½ in. dia. hole which was to pass over the branch core. This ring, which was ½ in. square in section, had three legs equally spaced, which were of such a length as to wedge into the mould forming the branch.

The procedure in assembling the mould was, of course, first to place the top part of the mould accurately in position, then the branch core was pushed through the opening on the outside of the mould, and the tapered end was pushed home. Then the special ring chaplet was pushed along the core to the position thought best, and the end of the branch closed by means of a cake core. It was necessary to take out the core-barrel before attempting to remove the casting from the mould. The time taken for making one of these castings was ten working days, the personnel being a moulder, an apprentice and a labourer. Of the inside of the pan only the plate forming the domed shape was saved. The casting was run from the top with flat gates.

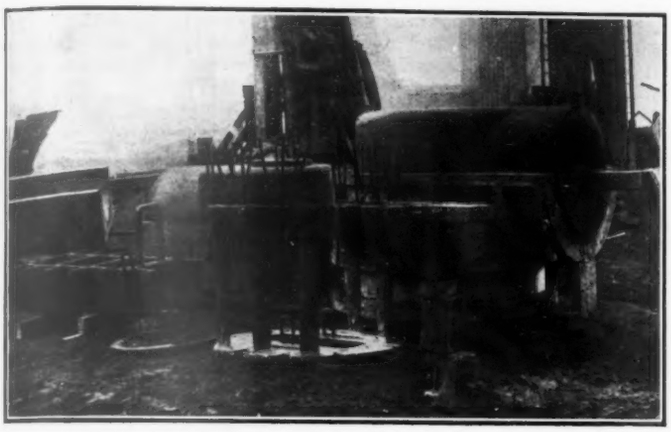

Fig. 28.—Core-Box, Core and Core-Iron for Three-Way Valve Casting.

Fig. 31.—Bottom Part of Mould for Acid Pan. Note Provision for withdrawing Casting without Disturbing all the Brickwork.

Fig. 29.—Spiral Rifling on Loam Core Marked by Means of String.

Fig. 30.—Acid Pan with Branch, weighing 6 tons, Dia. 7 ft. and Depth 7 ft.

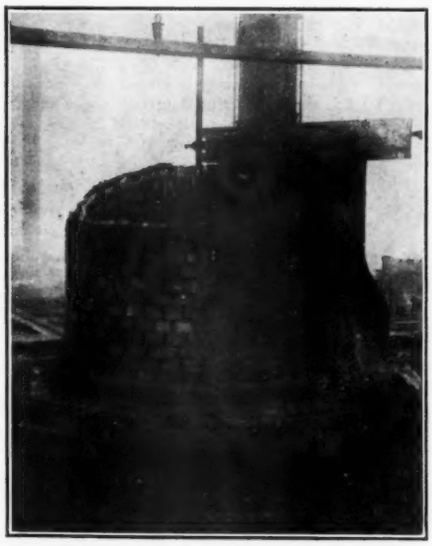

Fig. 32.—Top Half of Mould for Acid Pan.

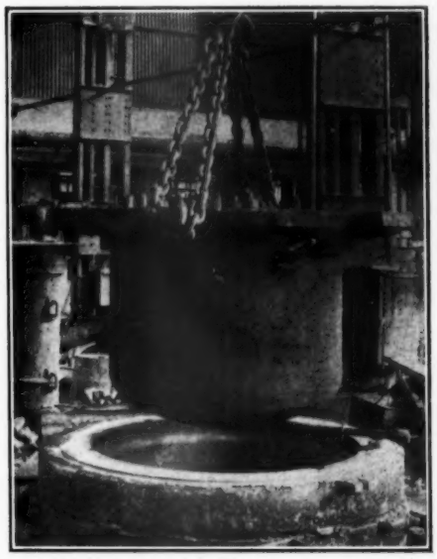

Fig. 33.—Top Part of Mould for Acid Pan being Lowered into Position.

It is not pretended that in this quick survey of moulding methods the question of detailed manufacture has been exhausted; much could still be said in explanation. If, however, this Paper helps to provoke discussion on moulding methods and the scope which a general engineering foundry is expected to cover, the labour of arranging the miscellaneous illustrations and the comments thereon will have been well worth while. It will not be forgotten, the author hopes, that the metallurgical side is required to complete the picture.

Mr. T. P. Cargill, managing director of the Anderston Foundry Company, Limited, Port Clarence, Middlesbrough, retired from active management of the firm at the end of October and is succeeded by Mr. G. D. Cunningham, director and secretary, whose secretarial post is being taken over by Mr. J. W. Finlay. Mr. Cargill, who is retaining his seat on the board, has spent 32 years in the service of the company, eleven years on Tees-side.

Refinement of the Structure of Castings

A GENERAL REVIEW OF THE PRESENT SITUATION

By Prof. A. PORTEVIN (Director, École Supérieure de Fonderie)

(*Continued from page* 312.)

FACTORS CAPABLE OF AFFECTING THE FINENESS OF THE SOLIDIFICATION STRUCTURE

This brief analysis of the phenomena of crystallisation leads to a better understanding and provides a foresight in certain cases of the possible intervention of various factors on the fineness of the solidification structure of metals and alloys.

The principal factors may be classified arbitrarily as follows:—

A.—*Mechanical Factors*: (1) Agitation of the liquid during solidification.

B.—*Thermal Factors*: (2) Thermal conditions of solidification. (3) Thermal history before solidification. (4) Repetition of the fusion.

C.—*Physical Factors*: (5) Electrical and magnetic influences. (6) Influence of pressure.

D.—*Chemical and Physico-Chemical Factors*: (7) Composition of the alloy, addition of foreign elements. (8) Incorporation or precipitation of nuclei or inclusions. Conversely sedimentation, centrifuging. (9) Action of fluxes and slags.

1. Agitation during Solidification

Agitation during crystallisation is a process much employed in industrial chemistry for "scrambling" the crystallisation and for producing small crystals. Agitation during solidification therefore tends to give a fine and disorientated structure. Agitation impedes the growth of the crystals and at the same time breaks them up, the particles detached forming so many fresh nuclei of crystallisation. At the same time, the temperature is rendered uniform. In short, agitation tends to re-establish isothermal conditions, to disseminate the nuclei and to obstruct the growth of the crystals, all of which are causes of fine and disorientated crystallisation. This agitation may be natural or artificial.

Natural agitation is that resulting from the fall of the molten metal during pouring, the circulation of the molten metal in the mould, mixing due to liberation of gas from the metal or from the mould or wash, thermal convection currents, etc.

Thus, according to Genders, in the pouring of ingots, the influx of hot metal counteracts the progression of the basaltic zone and detaches crystalline particles from its surface. As a result, there is at the centre of the ingot a mass having a tendency to crystallise from independent centres with the formation of equi-axial crystals.

If, in accordance with Bailey's experiments on bronzes with 5 per cent. of tin, the liberation of the dissolved gases does not appear to have any considerable influence on the macrostructure, this is not the case with unkilled steels which liberate a large amount of gas on solidification.

Genders has made a special study of the *turbulence resulting from the volatilisation of the facing of the mould and consequently the liberation of gases externally of the metal.* On casting an ingot of 70/30 brass of small thickness (25 mm.) in a cast-iron ingot mould with a volatile dressing having a resin base, the basaltic structure disappears in the upper two-thirds, which have a fine equi-axial structure with a central spongy zone. Without volatile dressing, there is a considerable increase in the basaltic structure and absence of fine equi-axial structure.

These results have been obtained with top-cast ingots and with bottom-cast ingots, showing that during the filling of the mould, the rate of volatilisation of the dressing is small compared with the rate of ascent of the metal in the mould.

With thicker ingots, however (50 mm.), the influence of the gases of the dressing is less evident, and disappears in the case of ingots 150 mm. thick. This action therefore depends both on the thickness and the height of the ingot.

Artificial agitation may be effected by various mechanical or physical means, and it is possible to vary either the direction of the agitation, shocks, vibrations, gyration, centrifuging or the rhythm or the frequency, that is to say, the number of cycles per second. Thus, for instance, the following may be employed:—Mechanical jolting by means of cams, but the frequency is low and the shocks of the heavy masses deteriorate the plant and cause splashing unless a solid crust is first allowed to form. "Vibrations" at frequencies above or below the audible limit, produced by means of vibrators introduced into the bath itself, the difficulties being the attack of the vibrator by the metal bath, the limited surface of contact whereby the transmission of the necessary energy to the bath is rendered difficult and the seizing of the vibrator by the solid metal. Sustained undamped "oscillations" of the metal and mould as a whole, mechanical oscillations (100 per second, for example) produced, for example, by two unbalanced weights rotating in opposite directions and secured to a platform which rests on rubber springs and on which are fastened the moulds (Deutsche Edelstahlwerke A.-G.), but capable of attaining by electro-magnetic excitation 10,000 per second of low amplitude.

Supersonic waves in particular, by their frequency and energy content, apparently ought to exercise a very effective action. S. Sokoloff (1935) found that the duration of solidification of molten zinc was reduced by 10 to 35 per cent. and that the structure was modified.

The effect of agitation on crystals is complicated by the effect on foreign particles or inclusions which may act as crystallisation nuclei. If the shocks and vibrations tend to maintain these particles in suspension and oppose their sedimentation, centrifuging on the contrary accelerates this sedimentation to a greater degree, the greater the speed of rotation, thus tending to eliminate them from the liquid.

2. Thermal Conditions of Solidification

These conditions are defined by the *rate of cooling* and the *temperature gradient* which qualify the variation of temperature with regard to time and space. Both of these two magnitudes depend upon numerous factors which affect the cooling and which have been termed *general casting factors* varying with the casting, the alloy, the mould and the pouring and surface conditions.

In the case of quiescent solidification (non-agitated liquid) of the same alloy poured under the same conditions, the solidification structure, as has been stated, depends upon the rate of cooling and the temperature gradient.

(*a*) The fineness of the structure, that is to say the number n of grains per unit volume, as a general rule increases with the rate of cooling.

(*b*) The general form and orientation of the grains depend upon the temperature gradient. A disorientation structure having equi-axial grains corresponds to a slight gradient, while an appreciable gradient tends to produce a structure having grains orientated and elongated normally to the isothermal surfaces.

Furthermore, the action of the rate of cooling and the temperature gradient may be estimated by means of the various types of test-pieces that are used for estimating the hardening properties of cast iron: test-pieces with variation in thickness or with local chill.

Thus, thin pieces cast in a chill mould, being of fine structure, give the best mechanical results especially after heat-treatment. To mention one example only, the following figures were obtained after quenching and annealing unforged aluminium-bronze test-pieces cast in chill moulds:—

Tensile strength $>$ 44.4 tons per sq. in. with an elongation $>$ 10 per cent.

Tensile strength $>$ 38.1 tons per sq. in. with an elongation $>$ 25 per cent. (Elongation measured on 4 ins.)

Chill casting likewise gives very interesting results with aluminium light alloys. For Alpax a fine structure is obtained with thin chilled castings without the necessity of a chemical refining treatment before pouring.

The results from the mechanical point of view, however, are only obtained by regulating the pouring temperature with regard to the other general casting factors, in particular the alloy, the shape of the casting and the feeding. In this way, not only is the solidification structure modified, but at the same time also the compactness of the casting and even the constitution of the alloy (intensity of the dendritic segregation and consequently possible variation of the proportion of the other constituents). The influence of the pouring temperature and the feeding of the mould on the mechanical properties and the structure, first pointed out by P. Longmuir in 1903 (for steel, cast iron, and copper alloys), has been shown by numerous investigators, for example the results of Francis W. Rowe (1924), Isidro Sans Darnis (1928), N. B. Pilling and T. E. Kilgren (1932) on ordinary and special bronzes and A. von Zeerlander (1935) on aluminium alloys, etc.[6] For cast iron, the problem is more complicated on account of the two states, stable and metastable. The influence of the pouring temperature has furthermore been examined by numerous authors (Hailstone, Honda and Murakami, Northcott, Oberhoffer and Stein, etc.).

3. Thermal History in the Liquid State, and 4. Repeated Melting and Initial State

It is thought that Le Chatelier was the first to draw attention to the influence of the temperature to which the metal has been raised in the liquid state independently of the state of oxidation which may result therefrom. From a micrographic examination of cast bronze with 10 per cent. of tin, he found that the crystals are more numerous and hence less developed, the less strongly heated was the metal. This fact, he added, "seems to indicate that the crystalline structures are not wholly destroyed immediately the fusion is completed." This persistence of crystal nuclei is confirmed by the experiments of Goetz and Webster.

Goetz and his collaborators (A. Goetz and M. F. Hasler, Phys. Rev. 1930, 36, 1752; A. Goetz and A. B. Focke, Phys. Rev. 1931, 37, 1044) have shown that a single crystal of bismuth, enclosed in a suitable tube, may be melted and then re-solidified without altering the orientation provided that the maximum temperature attained does not exceed the melting point by more than about 10 deg. C. Heating to a higher temperature results in a new orientation by cooling.[7]

W. L. Webster (Proc. Roy. Soc. 1933 (A), 140, 653) has shown that the tendency of bismuth and tin to exhibit supercooling increases with the temperature to which the liquid has been raised. The same effect has been observed but to a lesser degree with lead, but not with cadmium.[8]

It is not only the excess of temperature of the liquid above the melting point or "*liquid*

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superheat" which acts for this reason, but also the *length of stay in the liquid state* and *repeated melting*. These last two factors also contribute in reducing the number of centres of crystallisation and consequently in increasing the size of the grain. A very striking example is furnished with regard to repeated melting by the experiments of Carpenter on aluminium bronze.

Furthermore, in practical investigations on the influence of these factors, the chemical influences must not be forgotten, nor must those of the formation or elimination of particles in suspension or inclusions, which may result from variations in temperature and length of stay in the liquid state by the action of the molten metal on the atmosphere, the containers and fluxes and slags. These influences, which will be discussed later on, are added to the purely thermal influences and for the most part are cumulative through repeated melting.

It is particularly important to consider this with regard to oxidisable mixtures having numerous elements, such as cast irons, where the phenomena are complicated by the possible intervention of an internal equilibrium in the liquid state between the combined carbon and the elementary carbon or graphite, as the author pointed out at the Liége Metallurgy Congress in 1922.[9]

However that may be, the elevation of the temperature and the length of stay at that temperature of the molten cast iron act on the combined carbon content and the fineness of structure of cast iron, as shown by Prof. Piwowarsky (1925), Fritz Meyer and O. Wedemeyer (1926).

Finally, these influences, and particularly that of repeated melting, carry along with them that of the *initial state*, that is to say, that of the *structural heredity* through the fusions, but there again one must not forget the influence of possible chemical modifications, which may even be inaccessible to analysis, particularly of the foreign inclusions or nuclei.

5. Electrical and Magnetic Influences

Solidification corresponds to an increase in cohesion of the material. The forces of cohesion are forces of attraction between the atoms, and it is accepted that the latter are of an electromagnetic nature and consequently govern the texture of solidification.

Thus, the presence of an electric or magnetic field may have an influence on the electromagnetic forces of cohesion, determining the crystalline growth, an influence which would act on the rate of primary crystallisation, the grain size, etc. It would then be possible to effect the refining of the grain of the ingot during solidification either by passing a current through the ingot or by inducing the current by means of an external winding.[10]

6. Influence of Pressure during Solidification

Unpublished experiments effected at the Institut de Recherches de Fonderie for pressures up to 3,000 kg. per sq. cm. and experiments made by Welter with pressures attaining 20,000 kg. per sq. cm. show that the structure of various aluminium light alloys may be refined by exerting these pressures on the alloy during its solidification.

A very marked improvement is also found in the mechanical properties, both of the tensile strength and the elongation on rupture which may be doubled, but in this improvement it is not possible to establish the part due to the very pronounced increase in compactness, to the refining of the structure and to the possible displacement of the lines of solidification by the effect of the pressure.

It may be remarked that in the case of a gassy aluminium alloy containing 8 per cent. of copper Hanson obtained appreciable improvements in these characteristics by exerting gas pressures not exceeding 15 kg. per sq. cm.

7. Composition of the Alloy and Additions. 8. Incorporation, Modification or Elimination of Nuclei or Inclusions. 9. Action of Fluxes and Slags

The intentional, accidental or even unsuspected modifications of the chemical composition of an alloy are capable of exerting an important action on the structure of the alloy, but for the most part it is impossible to indicate the origin of this action owing to the multiplicity and complexity of the modes of action. The chemical composition or state may in fact exert an action in the following various ways:—

(*a*) Modification of the power of spontaneous crystallisation, that is to say, natural Nc or crystallisation velocity Vc.

(*b*) Modification of the progress of solidification without modifying the final constitution; modification of the solidification range or of the stages of solidification; appearance of a peritectic reaction.

(*c*) Modification of the physical properties such as the viscosity of the liquid phase (which is manifested as a modification of Vc) or the thermal properties (conductivity and diffusibility), which in particular changes the temperature gradient.

(*d*) Modification of the final constitution by the appearance of new phases or the disappearance of existing phases. As special cases, in which the generally undetermined impurities act, a particular place must be given to the following:

(*e*) Appearance (or disappearance) of precipitates or inclusions playing the part of crystallisation nuclei.

(*f*) Modification of the existing precipitates or inclusions; either modification of nature or form, division into finer precipitates or inversely agglomeration or coalescence to form coarser particles. This indirect action of the composition is connected to the direct action:

(*g*) Artificial incorporation of nuclei either identical or isomorphous with those of the alloy, or inversely mechanical elimination of existing inclusions.

(*h*) Likewise, the chemical modification or the action on the nuclei and inclusions may be either direct by addition or incorporation, or indirect by the action of a slag or flux acting on the metal bath by the operation of equilibria or reactions between the phases.

It is not possible for the author to review these various forms of action, which in general are superposed and react on one another. As it is consequently very difficult to isolate the elementary factors, it will be appreciated how difficult it is to analyse the total result, that is to say, the modification of structure resulting from a given action, such as the addition of an element to a metal bath or the modification of a melting condition. Generally, everybody considers one of the elementary phenomena and attributes the principal part to it, resulting in discussions which are for the most part sterile.

It is therefore proposed to indicate some established facts which are the result of these complex influences, at the same time mentioning the influence on certain elementary factors, without any attempt to prove in this way that there is a narrow relationship between cause and effect and that these factors are the predominant operative factors.

Thus, ferro-nickels and ferro-nickel-chromium and aluminium bronzes, which are poor conductors of heat and consequently increase the temperature gradient, very frequently give in cast ingots and bars basaltic and radial structures extending to the centre of the casting.[11]

It seems that, on the contrary, a considerable solidification range tends to oppose the formation of this latter structure, as has been found by comparing brasses with 68.5 per cent. of copper and 57.5 per cent. cast under identical conditions in sand and chill moulds. It is seen[12] that the peripheral zone of orientated or radial crystallisation is less developed in the brass with 68.5 per cent. of copper having a larger solidification range. This has also been found by Genders.

The important fact, however, with regard to the subject under discussion is that the addition of certain elements even in slight amounts refines the solidification grain of castings or modifies the solidification structure. Thus, cadmium suppresses the orientated structure of chill cast zinc (C. H. M. Jenkins). Titanium and cerium refine the solidification grain of aluminium castings,[13] vanadium, molybdenum and titanium that of steels, nitrogen that of ferritic chromium steels, sodium that of the aluminium-silicon eutectic (Alpax), etc.

As has already been remarked,[14] one should avoid confusing this refining action on the solidification grain with the refining action on the recrystallisation grain after cold working or allotropic transformation, the latter action being observed in forged or heat-treated alloys, while the former is observed in alloys as cast. Thus the cerium and titanium mentioned in connection with cast-aluminium have no action at all on the grain of rolled aluminium which, on the contrary, is refined by nickel and iron. Likewise, aluminium in small amounts refines and controls the grain of forged and annealed steels by retarding overheating.

(*To be continued.*)

REFERENCES.

6 See Appendices to the Cours de Métallographie by A. Portevin, at the Ecole Supérieure de Fonderie, 134, 135, 137, 139, and 263 *a* of the 1937 edition.

7 Hume Rothery considers that these experiments have been interpreted quite correctly by assuming that crystalline nuclei enclosing numerous groups of atoms persist in the liquid, and this is not surprising when it is remembered that bismuth is among the elements which follow the (8 — N) neighbours rule. If the atoms of each double layer are connected together by partially homopolar forces, it is to be expected that these double molecules will persist above the melting point and will then rupture at higher temperatures.

8 Hume Rothery remarks that here again it is evident that the crystalline nuclei persist, but this has no necessary and evident connection with a possible secondary structure of the solid.

9 A. Portevin, R.U.M., 1922, **15**, 308 and 522.

10 See Saklatwalla, "Iron Age," 1923, 112, 815.

11 A. Portevin, Bull. A.T.F., Sept., 1927, Figs. 21 and 22.

12 A. Portevin, *ibid.*, Figs. 19 and 20.

13 It is to this action of titanium and not to the degassing by the chlorine that the refining action of titanium tetrachloride on the grain must be attributed; the effect persists after remelting. Boron trichloride acts in the same way (Rosenhain, Grogan and Schofield).

14 A. Portevin, "La Fonderie Belge," Sept.-Oct., 1936, p. 487.

The Iron and Steel Institute

Arrangements have been made for an additional Autumn Meeting of the Iron and Steel Institute to be held in Cardiff on Friday and Saturday, December 2 and 3, 1938. The programme will include:—

(1) Technical session on Friday, December 2, at 7.30 p.m., in the Lecture Theatre of the South Wales Institute of Engineers, Park Place, Cardiff, with Mr. J. S. Hollings, joint managing director of Guest Keen Baldwins Iron & Steel Company, Limited (Vice-President), in the chair. Presentation and discussion of the following Papers:—"The Development of the Open-Hearth Steelmaking Processes in Recent Years in the United States of America," by L. F. Reinartz; "American Soaking-Pit and Reheating-Furnace Design and Practice," by F. M. Gillies and E. D. Martin. The proceedings will terminate at about 9 p.m.

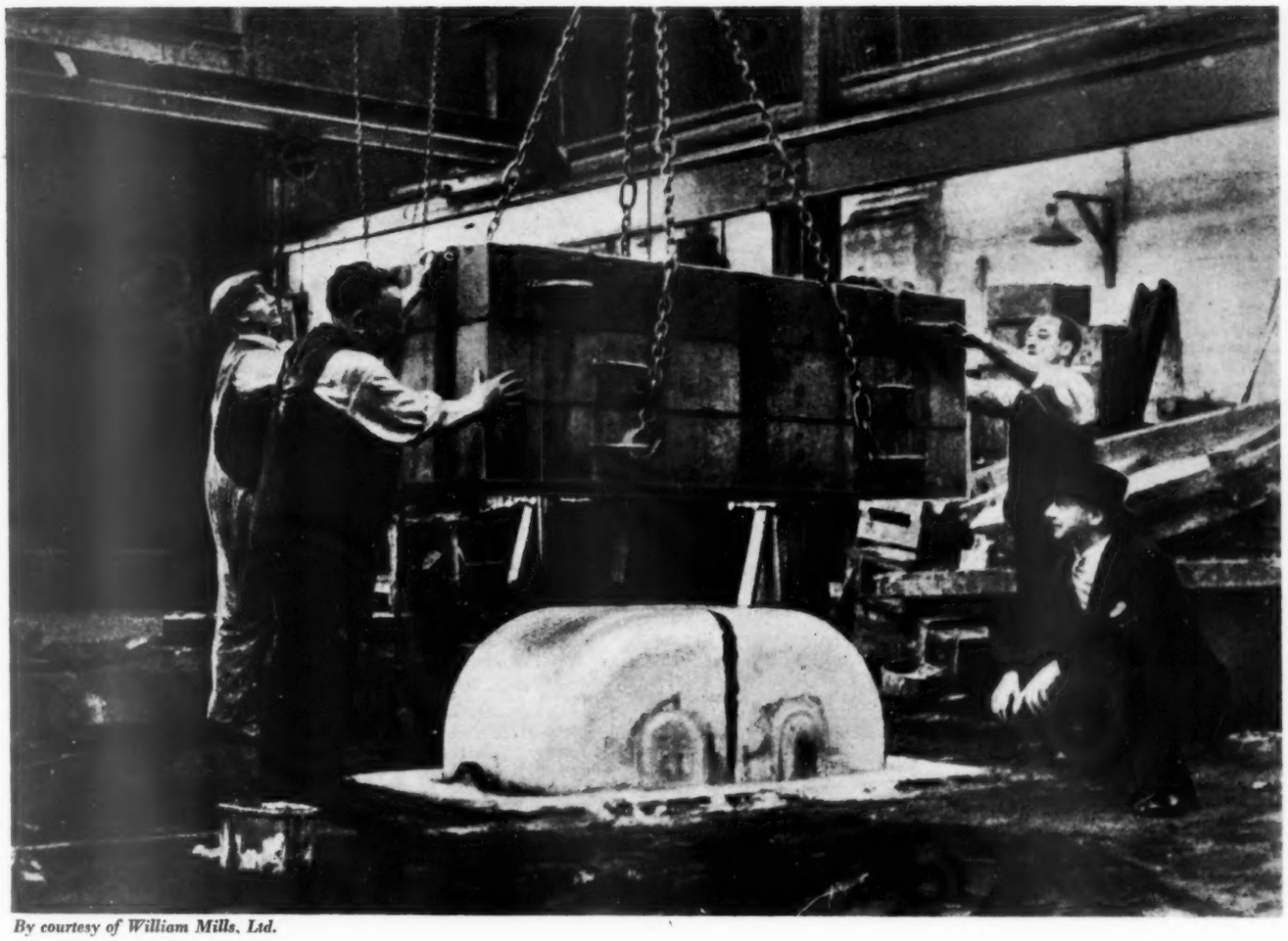
(2) Visit to the East Moors Works, Cardiff, of Guest Keen Baldwins Iron & Steel Company, Limited, on Saturday, December 3. The company will provide motor coaches for visitors who are not travelling by car.

9.15 a.m.—Motor buses will leave Cardiff Station and call at the Angel and Park Hotels.

9.30 a.m.—Arrival at the East Moors Works.

12.30 p.m.—Light refreshments at the works canteen by invitation of the company.

The visit will terminate at about 1.30 p.m. and buses will return to Cardiff in time to catch convenient trains.



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The Week's News in Brief

Trade Talk

THE DIVISIONAL OFFICES of the Iron and Steel Trades Confederation in Birmingham are now at Rooms 62 and 64, 174, Corporation Street.

THE FURNESS SHIPBUILDING COMPANY, LIMITED, Haverton Hill-on-Tees, have received an order from the Prince Line for a motorship of 9,200 tons deadweight.

GLENFIELD & KENNEDY, LIMITED, Kilmarnock, have received an order for 24 15-in. diameter telescopic sludge valves for northern outfall works of the London County Council.

THE 31ST PARIS INTERNATIONAL TRADE FAIR will be held from May 13 to 29 next. The number of exhibitors up to date shows an increase of 10 per cent. on last year's figure.

R. & W. HAWTHORN LESLIE & COMPANY, LIMITED, Hebburn-on-Tyne, have received an order for a 12,000-ton oil tanker for the Anglo-Saxon Oil Company. The firm will also supply the engines.

GEORGE COHEN, SONS & COMPANY, LIMITED, scrap iron, metal and machinery merchants, have inaugurated a contributory superannuation scheme for their employees and those of their subsidiary companies.

THE L.N.E.R. have recently placed three contracts of a total value of £230,000 in connection with the electrification of the line from Liverpool Street Station to Shenfield, together with the connecting line from Fenchurch Street Station to Stratford.

FERGUSON BROS. (PORT GLASGOW), LIMITED, have received an order from British owners for a single-screw coasting vessel designed for the carriage of petroleum in bulk. The vessel will be about 170 ft. in length and will be fitted with Diesel machinery

MEMBERS OF the social section of Callendar Ironworks, Falkirk, held their first social and dance in the Temperance Café, Falkirk, last Friday evening. Mr. W. Rattray (staff manager) presided over a gathering of 160, and songs, impersonations and elocution were given by members of the company. At the dance which followed, Mr. A. Chalmers acted as M.C.

THE "BERENGARIA," the 52,000-ton Cunard White Star liner, which has been bought by Sir John Jarvis, M.P., for a sum exceeding £100,000, is to be broken up at Jarrow. A new company, to be known as the Jarrow Shipbreaking Company, will be formed, and the greater part of Palmer's Yard has been leased from the Commissioner for the Special Areas for the work.

SIR W. G. ARMSTRONG, WHITWORTH & COMPANY (IRONFOUNDERS), LIMITED, of Close Works, Gateshead-on-Tyne, manufacturers of A.W. cylinder pig-iron, will in future not only supply a chemical composition certificate of each consignment, but will also include an etched photomicrograph at 200 diameters. This additional service is designed to act as a further safeguard against cases where the composition may be satisfactory but the structure is the reverse.

GJERS, MILLS & COMPANY, LIMITED, who found themselves compelled to lay idle, last May, the whole of the blast furnace plant at their Ayresome Ironworks, Middlesbrough, owing to the accumulation of heavy stocks of hematite, have now so far reduced the tonnage of undelivered material that they expect to restart two furnaces on the production of hematite before the end of the month. This will increase to twenty the number of blast furnaces operating on the North-East Coast, compared with 36 last December.

THE SITE, with factories, at Templeborough, situated on the south of the Sheffield-Rotherham Road, and owned by Sheffield Steel Products, Limited, has been considered by the directors of that company as too large for present requirements, especially in view of the resources of the company in other directions, and about 25 acres of the site, together with important buildings, has been acquired from that company by Thos. W. Ward, Limited, for development purposes. Although Sheffield Steel Products, Limited, are retaining a large and well-equipped factory, the property taken over by Thos. W. Ward, Limited, is a large and important factory site with extensive buildings, having siding connections with the main London & North Eastern Railway line.

Personal

MR. ERNEST E. BIRD has been elected a director of the Park Gate Iron & Steel Company, Limited.

MR. S. RUSSELL, a director of S. Russell & Sons, Limited, ironfounders, Leicester, has been elected to Leicester City Council.

MR. J. K. CLEMENT, a director of Thomas & Clement, Limited, ironfounders, of Llanelly, was married recently to Miss Mary Lewis, of Pontyates.

AMONG THE NEW Denny councillors recently elected was Mr. W. M. Shanks, son of ex-Provost Shanks, ironfounder, Denny. This is the third generation of the Shanks' family to be represented on the Town Council.

MR. A. SCHOLES, analytical chemist and member of the firm of Pattinson & Stead, Middlesbrough, has been nominated as President-elect of the Cleveland Institution of Engineers. For many years he has been an active member of the Council.

MR. EDWARD WALTERS SENIOR, J.P., has been appointed a local director for Sheffield of the National Provincial Bank, Limited. Mr. Senior is chairman and managing director of George Senior & Sons, Limited, and chairman of the Sheffield Forge & Rolling Mills Company, Limited.

MR. L. H. M. CRUMP, managing director of the Watford Foundry Company, Limited, was a candidate for the Bradshaw Ward in the recent Watford municipal election, and had the misfortune to be beaten by only 44 votes. He reduced to a narrow margin previous majorities of some 600 or 700.

SIR JOHN ANDERSON, who has joined the Cabinet as Lord Privy Seal, is a director of Vickers, Limited, and Imperial Chemical Industries, Limited. During the war he was secretary to the Ministry of Shipping. He has latterly been associated with A.R.P., being chairman of the Committee on the Evacuation of Civilians.

MR. P. B. LEVY, who has been appointed a director of George Cohen, Sons & Company, Limited, scrap iron, metal and machinery merchants, is a son of the firm's chairman and a great grandson of the founder of the company. Mr. Levy is 24 years of age, and joined the firm in 1932 after having spent some time abroad. In 1936 Mr. Levy was put in control of the power press and sheet metal working machinery at North Acton, and was responsible for the sale of his firm's products throughout the Empire.

Obituary

WE REGRET to announce the death on Sunday, after a short illness, of Mr. Denys M. S. Parker, managing editor of our contemporary, "The British Steelmaker."

MR. THOMAS BLACKADDER, of Falkirk, who died last week in Nice, where he had gone to spend the winter, was a partner in the firm of Blackadder Bros., brass and iron founders, of Falkirk. He was 73 years old.

MR. RALPH GEORGE BICKERTON, of Goole, died last week, aged 76. For many years he was a partner in the engineering and ship repairing firm of Webster & Bickerton, Limited, from which he retired about 12 years ago. He also founded the Goole Brass and Copper Works.

New Companies

(From the Register compiled by Jordan & Sons Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Cindal Aluminium, Limited, San Paulo Works, Mount Street, Nechells, Birmingham.—Capital £5,000. Directors: R. Noakes and P. Oakley.

H. W. Lindop & Sons, Limited, Junction Foundry, Pleck Road, Walsall.—Capital £25,000. Malleable ironfounders. Directors: C. A. B. and H. H. Lindop.

Tungstone Products, Limited, 10, Salisbury Square, London, E.C.—Capital £65,000. To acquire that part of the business of the late W. Haddon carried on as "The Tungstone Die Casting Company" at London and Market Harborough, and the trade marks "Tungstone." Directors: W. Haddon and H. T. Appleton.

Company Meetings

Lightalloys, Limited

The annual meeting of Lightalloys, Limited, was held in London last week CAPT. OLIVER LYTTELTON (chairman), who presided, said that during the past 12 months their turnover increased by over 20 per cent., due to the increased output which was possible from the extensions to works carried out last year, and to the satisfactory increase both in general engineering and in railway work. The volume of general orders had, indeed, been most satisfactory, and in the railway section of the business they had important contracts in hand for most of the companies in the United Kingdom. The range of their business was wide, and covered a host of articles in the general engineering trade, from the largest sand castings for marine engine work down to the smallest die castings of half an ounce in weight.

Wolverhampton Die-Casting Company, Limited

At the first annual meeting of the Wolverhampton Die-Casting Company, Limited, MR. ROBERT WHITEHEAD (chairman) said that the trade recession felt by so many industries at the start of this year naturally made itself felt on the company. The situation might at one time have been one for concern, but the directors tackled the matter energetically, and in the circumstances they regarded the profit as satisfactory. During the last few months there had been a steady climb in the call for the company's products. Indications were that this satisfactory position was likely to be maintained.

Herbert Morris, Limited

The annual meeting of Herbert Morris, Limited, was held at Loughborough on October 28, when MR. W. H. PURNELL, J.P. (chairman), said that during the year their works had been occupied continuously, and they had had the benefit of the extension to their North works. This had helped them to increase their output substantially. They had a satisfactory order-book which would provide them with work for many months to come.

Forthcoming Events

NOVEMBER 18.

Society of Chemical Industry (Chemical Engineering Group):—Joint meeting with Nottingham Section. "Refractories in Industrial Service," Paper by W. J. Rees, at Welbeck Hotel, Nottingham, at 7.30 p.m.

Institute of British Foundrymen

NOVEMBER 14.

Lincolnshire Section:—"Shrinkage of Cast Iron," Paper by A. A. Timmins, at Lincoln Technical College, at 6.45 p.m.

NOVEMBER 16.

East Midlands Branch:—Works visit to Midland Electric Manufacturing Company, Limited, Tyseley, Birmingham.

NOVEMBER 17.

East Anglian Section:—"Metallography in the Foundry," Paper by C. H. Kain, at North East Technical College and School of Art, Colchester, at 7.30 p.m.

NOVEMBER 18.

Lancashire Branch (Junior Section):—"Cardinal Points in the Production of Light Castings," Paper by J. A. Reynolds, at College of Technology, at 7.30 p.m.

Middlesbrough Branch:—"The Randupson Process of Cement Moulding," Paper by F. W. Rowe, at Cleveland Scientific and Technical Institution, Middlesbrough, at 7.45 p.m.

NOVEMBER 19.

East Midlands Branch:—"Mechanisation in the Foundry," Paper by P. C. Bleakman, at Technical College, Derby, at 6 p.m

NOVEMBER 19.

Falkirk Section:—"A Talk on Sands," Paper by T. Tyrie, at Temperance Café, Lint Riggs, Falkirk, at 6 p.m.

Wales and Monmouth Branch:—Report of Cast Iron Sub-Committee, presented by G. L. Harbach, at Technical College, Llanelly, at 6 p.m.

The Institute of Vitreous Enamellers

NOVEMBER 17.

Midland Section:—"Workable Control Systems and Benefits to Enamel Plants," Paper by J. E. Hansen (read by W. Todd), at Chamber of Commerce, New Street, Birmingham, at 7.30 p.m.

ONCE more the Season of Good Will draws nigh and though we would be loth to interrupt your thoughts of the festivities to come, we feel that in your own interests we must remind you that now is the time to order your supplies of Firebricks, Silica Bricks and Basic Bricks, etc., for your Christmas Repairs. Orders placed at once can be executed in time for Christmas, enabling you to avoid the delay and disappointment which so often accompanies last-minute demands for supplies.

Our Technical Staff is at your service for advice on any problem regarding the selection of the most suitable grade of refractories to meet your needs.

A FEW OF OUR PRODUCTS:

FIREBRICKS	SILICA BRICKS	BASIC BRICKS
GLENBOIG	LOWOOD	SAXPYRE
WHITE CARR	ALLEN	SPINELLA
HALIFAX	MELTHAM	DIAZITE
STOUR	BAWTRY	SUPERMAG

AMBERLITE INSULATING BRICKS, CEMENTS AND CONCRETES, ACID-RESISTING BRICKS AND CEMENTS, REFRACTORY CEMENTS AND SANDS OF EVERY DESCRIPTION.

GENERAL REFRACTORIES LIMITED,

GENEFAX HOUSE, SHEFFIELD, 10.

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Raw Material Markets

The future of the iron and steel trade will be more easily determined when prices have been fixed for delivery after the end of the year. It is expected that pig-iron consumers will be given the opportunity to make forward contracts within a few weeks' time, as next year's prices are likely to be arranged before the end of this month.

Pig-Iron

MIDDLESBROUGH. — Many users of foundry pig-iron have very little stock on hand and are only awaiting the producers' prices decision before entering into new contracts. Meanwhile, business is of a hand-to-mouth nature and no new orders extend beyond the next few weeks. Makers have substantial supplies to dispose of before the need of increasing production arises, but it is anticipated that they will keep a close watch on the position and will not hesitate to put into blast furnaces which were laid idle several months ago as the result of the slump in trade. Current business is based on Cleveland No. 3 G.M.B. iron at 109s. per ton, less 5s. rebate.

Hematite consumers are now rather busier and are calling for heavier deliveries under contracts. In most cases they have still a substantial tonnage to accept before contracts expire, and, thus, it is likely to be a considerable time before much new business is placed. In any case, users are awaiting an announcement with regard to future prices before booking ahead. As yet, the current restricted output is more than sufficient to meet the demand.

LANCASHIRE.—Rather more activity prevails in this area, and contract specifications are freer. New business continues to be on a week-to-week basis. Machine-tool makers and heavy electrical engineers are well employed and are expected to place substantial orders for iron as soon as future prices are known. Textile machinists, on the whole, are quiet, but those making castings for armaments are better placed. Hematite is in better request, but the tonnage passing into consumption is still comparatively small.

MIDLANDS.—High-phosphorus pig-iron is in better demand, but contract deliveries are still a long way behind schedule, and new business is not likely to amount to a very big tonnage for some time. Most users are taking deliveries more freely, and stocks are falling steadily. There is a good call for low-phosphorus iron, and the heavy engineers and machine-tool makers are taking heavy deliveries, while the jobbing founders are also fairly well placed in some instances and are using this type of iron on a good scale. Forward business is not generally being entered into, as the price varies considerably, and is a matter for negotiation at the time of making contracts. Current quotations range between £5 10s. and £6 10s. per ton, the latter figure being the price of Scottish iron. Hematite is in better demand, but existing contracts will generally cover consumers' requirements for a good time ahead.

SCOTLAND.—Light-castings foundries continue to work short time, about three to four days a week on the average. In October, only about 985 tons of pig-iron were shipped from the Tees to this district, a figure well below the average of normal times. Other consumers are rather better employed, and there are hopes that more orders for iron will be placed when forward prices are announced. Local steelworks are well covered and little business emanates from this source. On an average, steelworks are only working at about 60 per cent. of normal capacity.

Coke

Coke ovens have been doing an active trade recently and home demands have been supplemented by quite heavy calls from overseas consumers. The price outlook is uncertain; it is suggested in some quarters that there will be no reduction in prices during the winter, although many still anticipate lower prices after the turn of the year. For delivery to Birmingham and Black Country stations, best Durham foundry coke is quoted at 50s. 6d., with Welsh coke at a minimum of that figure.

Steel

The improvement in the steel market has been maintained and there has been an expansion in business in practically all departments of the trade. To some extent this is due to the requirements of the accelerated rearmament programme, but there has also been a revival in the demand for ordinary commercial purposes. The increased activity has been almost entirely confined to the home market, and overseas buyers continue to follow a cautious policy. The demand for semi-finished steel has broadened and the works turning out this class of material are better off as regards orders than for several months past. Although the stocks at some of the consuming works are still unwieldy, these are being steadily reduced and the outlook in this department has been considerably improved. In the finished steel section, conditions are brighter and buying has become more regular. A few forward contracts are being placed, but there is still a tendency to limit commitments until the prices which will rule after December 31 have been decided upon.

Scrap

The scrap market now presents a much more satisfactory appearance, but the bulk of the activity is still for cast-iron scrap. Although, in many districts, prices have been advanced, the demand continues to be quite strong. The steelworks are rather more active, but heavy stocks of scrap are on hand and it will be some time before new orders are placed.

Metals

Copper.—A rather quieter tone has prevailed in this market during the past week, but the undertone remains firm. It is anticipated that the copper statistics for the month of October will reveal a further reduction in stocks. This is certain to stimulate the market for a time. The trend of events in this country is ruled to a certain extent by the American situation. On the whole, conditions in the United States are steadily improving. Trade is reviving and the announcement that the utility concerns are entering into a huge programme of expenditure has enlivened the copper market. The American motor-car makers are actively employed and large tonnages of copper are being used by this section.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £45 12s. 6d. to £45 15s.; Friday, £45 11s. 3d. to £45 12s. 6d.; Monday, £45 16s. 3d. to £45 17s. 6d.; Tuesday, £46 2s. 6d. to £46 5s.; Wednesday, £46 12s. 6d. to £46 15s.

Three Months.—Thursday, £45 16s. 3d. to £45 17s. 6d.; Friday, £45 15s. to £45 16s. 3d.; Monday, £46 1s. 3d. to £46 2s. 6d.; Tuesday, £46 7s. 6d. to £46 8s. 9d.; Wednesday, £46 17s. 6d. to £46 18s. 9d.

Tin.—Interest is centred around the meeting of the International Tin Committee, which is due to be held on November 22. In all probability it will be decided to raise the quotas for the ensuing quarter. Business is still on the quiet side, but quotations have been well maintained and the tone of the market is firm. No doubt, the strict control of output is largely responsible for this strength. Trade is dull both on the Continent and in the United States.

Official quotations were as follow :—

Cash.—Thursday, £212 to £212 5s.; Friday, £212 to £212 5s.; Monday, £212 to £212 10s.; Tuesday, £212 5s. to £212 10s.; Wednesday, £212 10s. to £212 15s.

Three Months.—Thursday, £213 to £213 5s.; Friday, £212 15s. to £213; Monday, £213 to £213 5s.; Tuesday, £213 5s. to £213 7s. 6d.; Wednesday, £213 10s. to £213 15s.

Spelter.—Very moderate business has been transacted in this market during the week and demand has been at a low level. Consumers are expected to resist strongly the proposals to raise the import duty on zinc from 12s. 6d. to 30s. per ton. Until this question has finally been disposed of the market will remain in an unsettled condition. An interesting statement with regard to the import duty was made by Lord Horne at last week's meeting of the Imperial Smelting Corporation, Limited. He said that the Corporation was willing to make its contribution to an agreement between international producers of zinc. The scheme for an increase in the duty on imported zinc now being considered by the Import Duties Advisory Committee would, he said, in his opinion, be helpful in providing a basis for more fruitful co-operation to the benefit of interests in this country and abroad.

Daily market prices :—

Ordinary.—Thursday, £14 8s. 9d.; Friday, £14 8s. 9d.; Monday, £14 11s. 3d.; Tuesday, £14 11s. 3d.; Wednesday, £14 13s. 9d.

Lead. — The demand has been inclined to fall away somewhat recently and consumers now are showing little interest in new business. Exceptions to this are the armament makers, who are still in the market for quite substantial tonnages. Continental and Japanese orders continue to circulate freely. Although there has been no official announcement, it is believed in some lead circles that the Lead Producers' Association has actually brought restriction into operation. Curtailment of output is now being achieved, it is suggested. It is understood that the extent of restriction is not more than about 5 per cent.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 15s.; Friday, £15 15s.; Monday, £15 18s. 9d.; Tuesday, £16 2s. 6d.; Wednesday, £16 8s. 9d.

Scrap.—Little change has occurred in the scrap market and business continues to be rather dull. It is believed that the chief drawback to business is the fact that the prices which consumers are offering bear little relation to the intrinsic value of scrap. Prices of several grades have fallen slightly.

Approximate selling prices for old metal :—New aluminium cuttings, £70; rolled, £53; cast, £29; foil, £80. Copper, £39 to £44; braziery, £34 to £35; Brass (clean), £21 to £24. Zinc, £11. Lead, £14 10s. Gunmetal, £40 to £41.

Contracts Open

Croydon, November 14.—Cast and spun iron pipes and specials for twelve months from January 1. The Water Engineer, 70, Park Lane, Croydon.

Dorchester, December 5.—Iron castings, etc., for the year commencing April 1, 1939, for the Dorset County Council. The County Surveyor, County Offices, Dorchester.

Hucknall, November 14.—Cast-iron pipes and steel tubes during a period of 12 months, for the Urban District Council. The Surveyor, Council Offices, Hucknall, Notts.

Louth, November 16.—Supply and laying of 2,500 yds. of 6-in. dia. and 3,500 yds. of 3-in. and 2-in. dia. spun-iron mains, for the Louth Rural District Council. Mr. J. H. Haiste, Middleton Chambers, Lowgate, Hull. (Fee £2 2s., returnable.)

Windsor, November 14.—Cast-iron pipes and specials, street ironwork, etc., for the New Windsor Borough Council. Mr. F. N. McRae, borough engineer, 16, Alma Road, Windsor.

Exmouth, November 14.—Supply and erection of a 20-ton weighbridge, for the Urban District Council. Mr. H. S. L. Knight, engineer, Council Offices, Exmouth.

Liverpool, November 14.—Supply and erection of 150-kw. steam-generating set, for the Town Council. The Land Steward, Municipal Buildings, Liverpool.

Louth, November 16.—Supply and erection of duplicate borehole pumps and electric motors, for the Louth Rural District Council. Mr. F. J. M. Ingoldby, clerk, Council Offices, Cannon Street, Louth, Lincs. (Fee £1 1s., returnable.)

Penzance, November 28.—Manufacture and installation of filtration and pumping plant to be capable of dealing with a maximum quantity of 50,000 galls. per hr., for the Town Council. H. Lapworth & Partners, engineers, 25, Victoria Street, Westminster, S.W.1. (Fee £2, returnable.)

Wombwell, November 14.—Supply and erection of two electrically-driven centrifugal pump units of 25,000 galls. per hr. capacity, with pipework, switchgear, etc., for the Dearne Valley Water Board. The Engineer, Broomhill Waterworks, Wombwell, near Barnsley.